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Luz María JIMÉNEZ

# DESIGN OF A COLLABORATIVE INFORMATION AND COMMUNICATION TECHNOLOGY PLATFORM TO SUPPORT CREATIVITY IN INNOVATION ACTIVITIES - PROTOTYPING AND USER EXPERIENCE TEST

MONTREAL, DECEMBER 12TH 2013

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Mr. Mickaël Gardoni, Thesis Supervisor
Department of Automated Production, École de technologie supérieure

Mr. Antoine Tahan, President of the Board of Examiners
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Mrs. Sylvie Doré, Member of the jury
Department of Mechanical Engineering, École de technologie supérieure

Mr. Daniel Forgues, Member of the jury
Department of Construction Engineering, École de technologie supérieure

Mr. Clément Fortin, External Member of the jury
President and Chief Executive Officer,
Consortium for Research and Innovation in Aerospace in Quebec, CRIAQ

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**CONCEPTION D'UNE PLATEFORME COLLABORATIVE BASÉE DANS LES TECHNOLOGIES DE L'INFORMATION ET DE LA COMMUNICATION POUR SUPPORTER LA CRÉATIVITÉ DANS LES ACTIVITÉS D'INNOVATION - PROTOTYPAGE ET TEST DE L'EXPÉRIENCE-UTILISATEUR**

Luz María JIMÉNEZ

## RÉSUMÉ

Cette thèse porte sur la *Conception d'une plateforme collaborative basée dans les technologies de l'information et de la communication pour supporter la créativité dans les activités d'innovation - prototypage et test de l'expérience-utilisateur-*. Ces activités de recherche ont été développées pendant les sessions d'été 2010 à l'hiver 2013. Elles visaient à définir les détails de la démarche suivis pour la réalisation de cette thèse.

La problématique de la recherche a été construite à partir de l'analyse de trois défis observés dans les activités d'innovation, spécialement la collaboration créative des entreprises R-D et les équipes créatives de « Les 24 heures de l'innovation ». Ces défis devront être surmontés afin d'améliorer le processus de production collaborative des connaissances et le partage d'idées. Trois types de défis sont identifiés :

- *Communicatif :* la communication des connaissances pour l'innovation, qui devraient être transmises pour réussir à résoudre les problèmes complexes dans la proposition de nouveaux produits ou de nouveaux services ;
- *Organisationnel :* élaborer les stratégies de partage d'idées quand les participants sont distribués. Identifier les stratégies de gestion de connaissances que l'organisation des entreprises ou les équipes devront encourager afin de créer les plateformes de collaboration pour l'innovation ;
- *Technologique :* transmettre des connaissances tacites, non structurées et informelles, spécialement, en utilisant les technologies de collaboration, les technologies de l'information et de la communication (TIC), les outils collaboratifs Web 2.0 ou Web 3.0.

Les défis permettent définir deux dimensions de notre problématique de recherche : la dimension théorique et la dimension pratique ou technologique. La dimension théorique porte sur l'environnement des échanges d'idées et de connaissances qui supportent la collaboration créative. Les dimensions pratique et technologique sont considérées dans la modélisation de collaboration créative qui prendra la forme d'une plateforme pour les activités de production de connaissances et de partage d'idées.

Le but de cette thèse est de supporter les équipes créatives pendant leur processus de conceptualisation d'un nouveau produit orienté vers l'innovation. Les objectifs de recherche sont :

1. Déterminer les besoins des équipes créatives pendant l'étape de conceptualisation d'un nouveau produit
2. Proposer un système de gestion des connaissances (outils et connaissances) qui permet le support pour la production de connaissances tacites résultantes de la condition distribuée des membres des équipes
3. Modeler la plateforme qui supporte les besoins internes des équipes et de leur contexte à l'externe pour l'innovation
4. Proposer l'estimation de la collaboration créative par rapport à l'expérience utilisateur et les tâches réalisées par les équipes créatives dans le prototype TIC

Avec la revue de littérature du Chapitre 1, l'étude de la collaboration parmi les entreprises de R-D au Canada dans le Chapitre 2 et l'analyse des besoins des équipes créatives de « 24 heures de l'innovation » de novembre 2011 du Chapitre 4, le premier objectif sur la détermination des besoins des équipes créatives est atteint. Ainsi, dans le Chapitre 2 est défini le contexte de travail des équipes créatives en R-D, c'est à dire les conditions sociales et technologiques au Canada et les interactions de ces équipes pour l'innovation. La problématique définie et la méthodologie pour la réalisation de cette thèse sont présentées au détail dans le Chapitre 3.

Le deuxième objectif est atteint, d'une part, en analysant la production des connaissances dans les équipes créatives et en proposant un modèle conceptuel, extrait des observations directes de la compétition d’innovation « Les 24 heures de l’innovation ». D’autre part, en présentant un cahier des charges de la plateforme collaborative, basé sur le concept d’idéalité de TRIZ, qui consiste dans la projection de l’analyse de l’état de l’art de la technologie du support au partage de connaissances (Chapitre 5) en comparaison aux besoins des équipes créatives et les fonctionnalités utiles des technologies actuelles de l’information et de la communication (TIC).

Le troisième objectif est atteint en modélisant la plateforme collaborative et ses principales fonctionnalités, à l’aide du langage de modélisation unifié UML 2 dans le Chapitre 5. De la même manière, le quatrième objectif est atteint avec l’évaluation expérimental de de la plate-forme de collaboration. Le Chapitre 7 et le Chapitre 8 résument les résultats obtenus sur l’évaluation de l’expérience-utilisateur du prototype au moyen de : la validation des études de cas UML, l’analyse de tâches des fonctionnalités utilisées, l’analyse de la performance PAN (Performance Analysis) et le test d’utilisabilité.

Finalement, les autres sections de cette thèse sont les conclusions de la recherche, les retombées, la recherche future et les recommandations. Dans les annexes est inclus le plan d’éthique présenté au Comité d’Éthique de l’École de technologie supérieure et les résultats obtenus dans l’édition de « 24 heures de l’innovation » qui a eu lieu en mai 2012.

# DESIGN OF A COLLABORATIVE INFORMATION AND COMMUNICATION TECHNOLOGY PLATFORM TO SUPPORT CREATIVITY IN INNOVATION ACTIVITIES - PROTOTYPING AND USER EXPERIENCE TEST

Luz Maria JIMÉNEZ

## ABSTRACT

This research project reports the results of the thesis, *"Design of a Collaborative Information and Communication Technology Platform to support Creativity in Innovation Activities - Prototyping and User Experience Test"* and provides details of the procedure followed in realizing the thesis. The research was conducted between Fall 2010 and Winter 2013.

The research problem was based on an analysis of three challenges observed in innovation activities, especially at the level of creative collaboration among R&D enterprises and creative teams of "*Les 24 heures de l'innovation*". These challenges must be overcome before the knowledge production and ideas sharing process can be improved. Three types of challenges were identified:

- *Communication:* The communication of knowledge for innovation, which must be transmitted to successfully resolve complex issues, in the proposal of new products or new services
- *Organizational:* Development of knowledge management strategies for distributed idea sharing, which should be encouraged by the organization to create or support teams by means of a collaborative platform
- *Technology:* Transmission of tacit, unstructured, and informal knowledge, especially using collaborative ICT and technologies Web 2.0 or Web 3.0 tools.

This thesis investigates two dimensions of the research problem: the theoretical and the practical (technology issues). The theoretical dimension examines the environment for the exchange of ideas and knowledge, which supports creative collaboration in distributed conditions. The practical and technological dimensions involve a creative collaboration model which will take the form of a platform for creative teams.

The aim of this thesis is to support the creative teams in the process of conceptualization of a new innovation-oriented product. Through this thesis, we seek to:

- Determine the needs of creative teams during the conceptualization stage of a new product;
- Propose a Knowledge Management System (knowledge and tools) that enables the support of tacit knowledge produced in distributed condition of team members;
- Modeling a Platform that supports internal creative team's needs and the external context for innovation;
- Propose the assessment of the creative collaboration meaning the user experience testing and the realized task by creative teams on the ICT prototype.

We carry out a review of the literature in Chapter 1, a study of collaboration among creative R&D teams in Canada in Chapter 2, and in Chapter 4, we perform a knowledge needs analysis of creative teams in "Les 24 heures de l'innovation". These will enable us to achieve the first objective, the definition of the needs for supporting creative teams. Ultimately, we characterize the context of R&D activities in Canada, as well as interactions among creative R&D teams for innovation, with a theoretical study, by analyzing statistical data obtained from Statistics Canada. A detailed presentation of the problem statement and the methodology used for this thesis is provided in Chapter 3.

The second objective is fulfilled by analyzing the idea production process and the current ICTs, for proposing a conceptual model based on the observation of creative teams participating in "Les 24 heures de l'innovation" November 2011. On the other hand, by proposing the new specifications that support collaboration, we select a methodology based on the law of ideality (TRIZ), in which we observe the evolution of technological state-of-the-art of current functionalities (Chapter 5) in contrast with the needs and useful operations of ICT.

To realize the third objective, we model the collaborative platform, and its primary functionalities are presented using the UML 2, Unified Modeling Language, also we describe the prototype deployment at Chapter 6. The fourth objective is reached by an experimental evaluation of the platform that is presented in Chapter 7 and in Chapter 8. These chapters summarize the results obtained by the application of the following user experience test: validation of UML use-cases user's acceptance, the task analysis of the main used functionalities, the creative performance Analysis of user (PAN) and the usability test.

Finally, the other sections of this document are the conclusion, findings, proposals for further research, and recommendations. In the Appendix, we include the ethical plan presented to the École de technologie supérieure Ethical Review Board, as well as the results obtained from "Les 24 heures de l'innovation" of May 2012.

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| | |
|---|---|
| CAD | Computer-Aided Design |
| CMC | Computer-Mediated Communication |
| CSCW | Computer Supported Cooperative Work |
| EMS | Electronic Meeting Systems |
| GSS | Group Support Systems |
| ICT | Information and Communication Technologies |
| KM | Knowledge Management |
| KMS | Knowledge Management System |
| OS | Open Source |
| PAN | Performance Analysis |
| PHP | Personal Home Page (Scripting Language) |
| R&D | Research and Development |
| RIVI | Red Interactiva Virtual de Innovación Universidad Nacional de Colombia |
| SME | Small and Medium-size Enterprises |
| SMS | Short Message Service |
| TRIZ | Theory of Inventive Problems Solving |
| UML 2 | Unified Modeling Language 2 |
| VIIN | Virtual Interactive Innovation Network |
| Web | World Wide Web |
| Web 1.0 | Global Hypertext System on Internet |
| Web 2.0 | Collaborative online sharing and Social Media |
| Web 3.0 | Web-based tools, Cloud computing and Semantic Network |

# INTRODUCTION

From 1993 to 2006, I was Professor of Creativity at the Universidad Nacional de Colombia in Manizales and an active member of the Creative Management team. In 2003, the team was invited by the university board to participate in the activities of the "Parque de Innovación Empresarial"[1], which promotes innovative entrepreneurship among students. The Park was led by Professor Johnny Tamayo, an expert in Information and Communication Technologies (ICT), who implemented new collaborative tools in the Park's activities. At the time, I was also co-lead for the third year workshop at the Department of Industrial Engineering. During the workshop, students worked together with academics and project managers from local industries. By common consent, we proposed introducing the available ICT platform of the Park in the workshop and training more than 75 students. For the project, we chose the Open Source groupware (OS) DotProject, a project management tool. After using DotProject for one academic semester, I submitted a research project to the administration: *Red Interactiva Virtual de Innovacion (RIVI) (Virtual Interactive Innovation Network VIIN).* This project was mainly supported by the National University, which provided computer and physical infrastructure worth $CAD500,000 (Jiménez and Vargas, 2004; Jiménez, Vargas and Tamayo, 2004, p. 154). The RIVI project consisted of a platform for interactive work which allowed teachers, students and entrepreneurs working in partnership to outreach university projects.

After a year of hard work, and despite active student participation, enthusiasm for ICTs was waning. The use of ICTs for collaboration, which initially had many advantages for University services and companies, presented some drawbacks mainly due to:

- A significant drop in participation among a large portion of project managers;
- A lack of use of computer networks or difficulty accessing them;

[1] For more information, visit the Web site: http://parque.manizales.unal.edu.co/index.php or the Facebook Page https://www.facebook.com/ParqueInnova.

- The heavy workload that was added to our usual fare (ICT involves the consolidation of tacit information to render it explicit and accessible). Using the keyboard to enter all information took time, as compared to verbal and interpersonal communication during business visits;
- The fact that groupware imposes a different kind of organization (Jiménez and Vargas, 2004).

**Research motivation and goal**

In 2006, I presented the project, "Espaces virtuels pour l'innovation" (*Virtual Spaces for Innovation)*, sponsored by Fonds Québécois de la Recherche sur la Nature et les Technologies, FQRNT (2007-2010), because I found the same drawbacks in the use of ICT in Quebec enterprises as what I had observed in Colombia. This thesis was born out of my desire to know what had happened in the RIVI project (described above), and to establish a means for supporting collaboration. These elements are at the root of our interest in identifying the issues involved in sharing creative ideas in a distributed context as well as in contributing to the development of new methodologies for innovation in R&D projects, particularly in the early design stage, when knowledge production and ideas sharing remain informal and non-structured.

In this research, our main question is: *How can we support the distributed creative collaboration, using a knowledge management system and a collaborative ICT platform for ideas sharing?* The problem statement is broken down into two dimensions:

***Theoretical dimension:*** Improving a knowledge management system for the exchange of tacit knowledge to support distributed creative collaboration.
***Practical and technological dimension:*** Developing an ICT platform for creative teams based on a knowledge management system that supports creative collaboration.

As indicated above, this thesis is broken down into eight chapters, presented as follows:

In Chapter 1, we present a review of the literature, which introduces the most common concepts that will be used in our thesis and the study of the theoretical models proposed to understand innovation and creative collaboration. Also, we review eight theoretical models to explain the innovation process. All these models converge to concepts as: knowledge production, interactive learning, and the use of ICT in the new knowledge economy.

In Chapter 2, we analyze a case study of R&D in SMEs in Canada. Creative R&D teams include strategies based on expert thinking and informal association, such as seeking critical expertise, using their "embedded knowledge". Knowledge capture for innovation is acquired from associations, trade fairs and the Internet, summarizing a dynamic based on an informal and non-permanent network.

In Chapter 3, the theoretical models and case study results are compiled to structure our problem statement. Also, we present the methodology used to achieve the research objectives. The theoretical results are validated through a study of needs and ideals required for creative collaboration. Data was collected from the creative teams of two editions of "Les 24 heures de l'innovation", an international competition organized by ÉTS: May 2011 (150 participants) – description of ICT needs and Tools, November 2011 (250 participants) – ideals and knowledge needs, and May 2012 (850 participants) – prototype testing.

In Chapter 4, we describe the knowledge sharing needs of creative teams working on a new R&D product. We found that they prefer to seek expertise in defining the project concept, but that they do not maintain constant communication with experts or organization staff. Creative teams prefer capture knowledge from Internet as a kind of Technology Watch method. Teams reported wide variations in the use of ICT to share knowledge and ideas. This information allowed us to model the collaboration process using an ICT Platform.

In Chapter 5, we model the main functions and characteristics of an ICT platform that supports creative collaboration dynamics using the UML 2 language. UML 2 allows us to anticipate possible use cases and the form of interaction among participants, through: 1) Communication, time management, task assignment components; 2) The definition of components and architecture of the system using expected results and communication tools; 3) The use of applications to share files and collaborative tagging systems during the ideas generation and sharing process.

In Chapter 6, we follow the trend of technology evolution proposed applying the Ideality Law (TRIZ approach) to define the current state-of-the-art of collaborative tools. We select the main functionalities in the Web 2.0 and Web 3.0 technologies that could be integrated into a cross-platform. This analysis allows us to define the prototype of the collaborative platform, InnoKiz (Keys of Innovation) that incorporate some new functionalities that are not yet available as ideas generation or evaluation tools.

In Chapter 7, we compare the functionalities modeled with functionalities implemented on a PHP Platform (developed by Clément Jacquot), and a test of UML validation use- cases and task analysis used to define the collaboration and the communication patterns produced among 24H teams.

In Chapter 8, we present a performance and usability test carried out to define functionalities that are perceived as useful by users. We assess collaborative performance as an index composed of four metrics: perceived creative performance, perceived team performance, perceived usefulness, and perceived accessibility.

Finally, in the Conclusion and Recommendation Sections, we underline the main findings of this thesis, and propose some possible avenues of future research work.

# CHAPTER 1

# CONCEPTUAL FRAMEWORK AND THEORETICAL INNOVATION MODELS REVIEW

This chapter presents the conceptual framework for creative collaboration (main terms used in this thesis) and a review of the literature on the knowledge production process in eight innovation models. These models break down into three concepts related with: knowledge production, social interaction, and needs of media support in the process of innovation. This first chapter is complemented by Chapter 2, which presents an analysis of the context of R&D enterprises in Canada. This study was developed using data from Statistics Canada to examine collaborative activities for innovation. This knowledge-based approach enables modeling triggers interactions among R&D enterprises and their context to build networking and organization. Our aim is to define what creative collaboration takes place in an innovative context.

## 1.1 Theoretical framework for the study: Idea, information and knowledge

A conceptual framework is "the system of concepts, assumptions, expectations, beliefs, and theories that supports and informs [a] research" (Maxwell, 2004, p. 33). This framework is a "tentative theory" (idem) that delimits this study. Initially, the basic concepts to be defined are: idea, data and information, knowledge production, and creative collaboration. Later in this chapter, the main models of knowledge production in an innovation context will be discussed.

### 1.1.1 Idea

The word *Idea* comes from the Greek *eidos*, which means *visible form or pattern*. This concept denotes "a subjective, internal presence in the mind, somehow thought of as representing something about the world" *(Oxford Dictionary of Philosophy, 2008, p. 177)*; it also "represents an eternal, timeless unchanging form or concept: the concept of the number series or of justice, for example, thought of as independent objects of enquiry and perhaps of knowledge" (idem). These two definitions make the concept of idea "a notion stretching" from A to B (idem) because it has many meanings and interpretation problems. In a design context, the first definition is more commonly used, because *idea* refers to insights or answers to problems, especially technological dilemmas. These problems are characterized by their complexity because they affect social development, in addition to posing economical and technical challenges. The production of a new idea is at the core of a creative process. A creative idea is recognized if at the time it provides a new meaning, an original answer and no statistical correspondences exist with another known answer. An idea could be expressed "in a word, a phrase, a sentence, or indeed any verbal proposition, but it may be something expressed in a gesture, a figure, a drawing, or a particular action" (Carroll, 1993, p. 394). An idea could be considered creative when it gives another meaning, another answer or another expression to the problem (ibid). A creative idea expresses something different from the usual information obtained by simple analysis. In that sense, an idea constitutes tacit knowledge in the mind, which is transformed as a seed of explicit knowledge when it is socialized.

### 1.1.2 Data and information

Data is a notion or a fact that could be represented by conventional symbols or by an interpretation system. These symbols are easily processed or stored, and allow an automated usage process. Information is basically data, with which it shares characteristics: transmissibility, storability, and reusability. Information refers to the action of modeling or giving a form to data (CNRTL, 2009); essentially, information gathers a new organization into data, making the data meaningful.

Despite the similarities between data and information, Sage (2003) argues about "the distinction between data, information […]. Data represent points in space and time that relate to particular aspects. Information is data that are potentially relevant to decision making; it relates to description, definition, or outlook. Generally, information is responsive to questions that relate to "what,", "when", "where", or "who" (ibid).

In an engineering context, information relates to the process of recognizing and having a "better understanding of knowledge. It can lead to better decision making and problem solving in design" (Xu et al., 2011). The information must be presented in a comprehensive manner.

### 1.1.3 Knowledge

Underlying the definition of knowledge is an ongoing discussion concerning the history of philosophy. The meaning of knowledge corresponds to the paradigms and beliefs of human thought. The multifaceted definition of knowledge can be observed for the different common definitions, as seen in Table 1.1. The definitions seem to identify knowledge with the mental model or the paradigm of the community where the knowledge was created or conceptualized. Table 1.1 shows an overview of different notions of knowledge. These notions are connected to social approaches or brands of philosophy. In some cases, many definitions are related to epistemology, the branch of philosophy which studies the nature and the production of scientific knowledge. There is a tripartite vision of knowledge, which consists in a basic analysis of a proposition to identify its consistence as knowledge. For a proposition to be considered as knowledge, it must have "three individually necessary and jointly sufficient conditions: justification, truth and belief. In short, propositional knowledge is justified through belief" (Moser, 1993, p. 2).

Pursuing the same comparison of data and information, we can define knowledge as the structure used to organize information in a comprehensible manner for a community validation, in a given social or historical context. Knowledge also describes the structure of the intellect, in a cognitive approach and in other cases; it is related to the structure of the science. Any of these notions can fully explain the description of knowledge, although none of them may accurately define knowledge production.

Table 1.1 Knowledge Notions in quotations

| **Common notions** | **Resource** |
|---|---|
| "The fact or condition of knowing something with familiarity gained through experience or association" | Encyclopedia Britannica, 2011 |
| "The range of one's information or understanding" … "The fact or condition of having information or of being learned" | Encyclopedia Britannica, 2011 |
| "The circumstance or condition of apprehending truth or fact through reasoning" | Encyclopedia Britannica, 2011 |
| **Philosophical notion** | |
| "We think we have knowledge when we know the cause, and there are four causes: (1) the definable form, (2) an antecedent which necessitates a consequent, (3) the efficient cause, (4) the final cause" | Aristotle (384-322 BC). Posterior Analytics Book II, Chapter 11, 94a, [20] in Gaither and Cavazos-Gaither (2000) |
| **Epistemological notion** | |
| One can only understand the essence of things when one knows their origin and development. | Oparin, A.I. Life: Its Nature, Origin and Development. Chapter I (p. 37) in Gaither and Cavazos-Gaither (2000) |
| "We should have to represent the tree of knowledge as springing from countless roots which grow up into the air rather than down, and which ultimately, high up, tend to unite into one common stem" | Popper, Karl R. *Objective Knowledge* Chapter 7 (pp. 262-3) in Gaither and Cavazos-Gaither (2000) |
| "Science is organized knowledge …" | Spencer, Herbert. *Education.* Chapter II (p. 119) in Gaither and Cavazos-Gaither (2000) |
| **Knowledge in a context** | |
| "People who confuse science with technology tend to become confused about limits … they imagine that new knowledge always means new know-how; some even imagine that knowing everything would let us do anything" | Drexler, K. Eric. *Engines of Creation.* Chapter 10 (p. 148) in Gaither and Cavazos-Gaither (2000) |
| "subjective and valuable information that has been validated and that has been organized into a model (mental model); used to make sense of our world; typically originates from accumulated experience; incorporate perceptions, beliefs, and values" | Dalkir (2005, p. 336) |
| "The result of human experience and reflection based on a set of beliefs and residing as fictive objects in people's minds". | Gardoni (2005, p. 56) |
| "To construct a model of design knowledge as a structured system of the theoretical and conceptual elements preceding the activity of design ... Through objects, artifacts, equipment, and building design can also contribute to the outline of a non-material culture that will be more in accordance with principles pertaining to life quality and human well-being" | Jiménez-Narváez (2000, p. 8) |

### 1.1.4 Knowledge Production

In general terms, knowledge activities could be classified under *knowledge production* and *knowledge acquisition or transmission* (Dalkir, 2012; Tödtling, Lehner and Kaufmann, 2009;

Wallace, 2007). *Knowledge production* refers to the proposition of an idea that should be evaluated to solve a specific problem. Philosophically, the methods for knowledge production are models of scientific research, such as hypothetic-deductive, inductive, and abductive reasoning models. *Knowledge acquisition or transmission* implies other cognitive activities, such as perception, reasoning, learning, communication, experience, memory, and witnessing. Finally, knowledge is defined depending on its close relation with the context of the people who work with or who create with it. Also, knowledge can comprise the terms "approach, method, practice, or strategy" (Sage, 2003). This practical aspect of knowledge enables us to proceed with an active approach to knowledge production, in the sense that "knowledge responds to questions that relate to "how"." It is sometimes desirable to isolate wisdom as an even higher-level construct that represents insights, prototypes or models, or principles which would be responsive to questions concerning "why". If this distinction is not made, knowledge is expected to respond to "why" questions as well as to those relating to "how" (ibid). This particular aspect of knowledge is of special interest in our research, as presented in the following section; we briefly explain this practical incidence on the creative production of ideas.

## 1.2 Knowledge objects in design process

In design theory, there are models that explain a cognitive design space formed by knowledge objects or "cognitive artifacts" related to internal and external representations (Visser, 2006). For Rittel (1971), besides skills and judgment capabilities, there are two kinds of knowledge objects: "Factual knowledge and Knowledge of problem" (p.16). In the approach by Simon (1979) to information systems, the knowledge stored could be transformed by the expert, and the associated strategies into "perceptual clues", "semantically rich domains" and "production systems" (p. 367). In a more pragmatic approach, MacLean et al. (1991) proposed three objects: Questions, Opinions and Criteria, as a result of design interaction. This model, known as "QOC", describes an argumentative activity which is specific to a *"Design Rationale".* This *design rationale* model was proposed by Kunz and Rittel (1970) to establish the need for an "Issue-Based Information System" that supports the following four categories of information exchange during the resolution of a design problem:

- "[... interactions] between the participants (opinions, expertise, reference to previous questions and decisions, similar questions, etc.)
- [... interactions] with experts about specific questions
- Information from documentation systems (for literature support of a position, for factual reference, etc.)
- In the case of dependent cooperatives: with the client or decision maker (directives, quest for decisions, reports, etc.)" (Kunz and Rittel, 1970, p. 2)

In the context of creative problem solving, introducing new ideas always involves changes, not only for the proposition of the solution, but even for the ways in which a design team works. Usually, the resolution of conflicts involves problem solving strategies and teamwork. Complex problems, also called ***Wicked Problems*** or ***Planning Problems*** (Rittel and Webber, 1973) or ***Ill-defined*** or ***Ill-structured*** problems (Simon, 1973), imply active interaction among those involved in problem resolution (users, stakeholders, suppliers, distributors). The complexity of the problem depends on the socio-technical dimension, the size, and the nature of the community concerned, as well as the tools, devices or any technological infrastructure available in the community. Also, creative-complex problems represent the cognitive context in which the participants find creative inspiration (De Michelis, 1997; Sternberg, Kaufman and Pretz, 2002).

For Rittel and Webber (1973) or Simon (1973), the design problem is resolved in an interactive cycle until achievement of a "satisfactory response" to the problem, but is neither the only solution nor the exact one. This knowledge cycle in a design process can be synthesized in six units that have to be exchanged:

1) Problem definition: abstraction of information to define the new product/new service
2) Information input: sharing needs, expectations, dreams, insights around the problem
3) Idea proposal: possible ideas that could solve the problem
4) Defining requirements: defining the criteria based on initial inputs
5) Idea elaboration: representation of ideas with details to be realized in a real situation
6) Interactive evaluation: each new element added is assessed to satisfy each criterion

The above units into the knowledge cycle generate an *object of knowledge*, which "is the basic element. It is an atomic packet of knowledge content that can be labeled, indexed, stored, retrieved, and manipulated" (Wu, 2009, p. 366). For Merrill (1998) "a knowledge object is a way to organize a database (knowledge base) of content resources (text, audio, video, and graphics) so that a given instructional algorithm (predesigned instructional strategy) can be used to teach a variety of different contents" (p. 1). Also, a particular characteristic of knowledge objects is that they "should consist of components that are not specific to a particular subject matter domain" (idem). In Table 1.2, the nature of each object of knowledge is modeled by three knowledge taxonomies adapted from: the model of knowledge transfer of Paquette (2002), the knowledge forms of Wiig (1993 in Dalkir, 2011), and the knowledge extraction of Hoc (1991). The knowledge flow in the design process is thus identified. The scope of this process is determined by the kind of knowledge and resources mediated to support the whole knowledge design cycle. This theoretical information will be explored in a research study about design teams in Chapter 4.

In Table 1.2, we observe that the nature of knowledge of design objects corresponds closely to a tacit and embodied/personal knowledge. This knowledge has to be shared or validated in a collective action to produce new design knowledge. This evolution in the knowledge flow in design has been misunderstood and not effectively supported. Innovation support systems (enterprise intranets, product CAD/CAM data-bases) are focused on the use of product information, methods, and taxonomies of product components or production processes, but not on the interactive cycle of knowledge production or the social dynamics in design.

In Section 1.3, we define "Knowledge Management System" concept. Then, in Section 1.4, we compare eight general models that explain the knowledge flow for innovation. This comparison allows understanding the interplay between the knowledge production process, the social interaction, and the support systems for the innovation.

Table 1.2 Knowledge Objects in a Design process

| Knowledge Object | Models of knowledge classification | | | | |
|---|---|---|---|---|---|
| | **Knowledge system (Paquette, 2002)** | **Form of knowledge (Wiig, 1993, cited by Dalkir, 2011, p. 81)** | **Extraction of knowledge (Hoc, 1991)** | **Social interaction** | **Procedural activity** |
| **1. Information inputs: needs, expectations, dreams** | Declarative | Factual / Expectational | Declarative | Public, Collective | Iterative (external and internal knowledge) |
| **2. Problem definition: abstraction of information to define the new product** | Procedural Relational principles | Conceptual | Conception situation | Collective – Consensus and discussion | Parallel Internal reflection and abstraction – |
| **3. Ideas proposal: possible ideas that could solve the problem** | Conceptual knowledge | Conceptual | Anticipation | Personal | Iterative |
| **4. Defining requirements: criteria definition based on initial inputs** | Prescriptive knowledge | Methodological | Domain knowledge | Collective | Sequential |
| **5. Idea elaboration: representation of ideas with details to be realized in a real situation** | Declarative knowledge | Factual | Anticipation | Personal | Sequential |
| **6. Interactive evaluation: each new element added is assessed to accomplish with all criteria** | Prescriptive knowledge | Methodological | Domain knowledge | Collective | Iterative |

## 1.3 Knowledge Management Design System

A Knowledge Management System (KMS) is defined as the set of technologies used to develop an activity. A KMS often relies "on groupware technologies, which facilitate the exchange of organizational information, but emphasize identifying knowledge sources, knowledge analysis, and managing the flow of knowledge within an organization - all the while providing access to knowledge stores. A system or tool that manages the sum of all knowledge within the organization as its “intellectual assets” (Dalkir, 2012, p. 469). Within the framework of this thesis, the Knowledge Management System corresponds to the socio-technological system that creative teams have to put in place to obtain knowledge resources to generate ideas and sharing among teammates and with their partners. Modeling the KMS of the design process is a main scope of this thesis; it will be described later on Chapter 5.

### 1.4 Knowledge production in an innovation context

The knowledge production model or method has received increased interest in recent years. This is due not only to the description of the knowledge production process, but also to the increased importance of innovation activities for academia and industry alike. In a context of innovation, knowledge production and management requires an extended analysis to answer the following question: In what sense does the production of knowledge generate innovation? In the context of innovation, several models have been proposed to define the importance of knowledge production in the innovation process. In the following sections, representative models or frameworks of new collective knowledge production in a socio-technological system are presented. We will emphasize the characteristics and interactions generated by interactive dynamics when knowledge is produced collectively.

#### 1.4.1 Innovation as Knowledge production by Amin & Cohendet (2004)

Innovation “can be regarded as the main outcome of knowledge production” (Amin and Cohendet, 2004, p. 15). Moreover, innovation is the process of introduction of a new product or a new process on the market, and for that reason, the production of knowledge can occur in a social, contextual, and interactive process, where the knowledge cannot be considered separate from its owner or without temporal or spatial location (ibid, p. 23). The knowledge consolidation process includes three stages: “design of models, languages and messages” (idem). The first two aspects, models and languages, have high fixed costs. The final aspect, messages, requires agents responsible for operating the movement of knowledge; in this case, costs are marginal if messages are reproducible, if the message is new, the costs will be higher (ibid, p. 21).

### 1.4.2 Knowledge production by Nonaka & Takeuchi (1995)

> "The organization cannot create knowledge on its own without the initiative of the individual and the interaction that takes place within the group. Knowledge can be amplified or crystallized at the group level through dialogue, discussion, experience sharing, and observation" (Nonaka and Takeuchi, 1995, p. 13).

Nonaka et al. (1997) studied the process by which Japanese managers produce new knowledge. They describe three characteristics in the production of knowledge: 1) the use of metaphors and analogies: "people use with confidence the figurative and symbolic language to express what is hardly expressible" (p. 30, free translation); 2) the dissemination and sharing of knowledge in the organization: "the new knowledge is always initiated by an individual and this individual knowledge is transformed into organizational knowledge, which can be valued by the company as a whole" (p.31); 3) under certain conditions, depending on the organizational communication processes, new knowledge may be presented in a redundant or ambiguous manner. Ambiguity "may sometimes be useful, not only as a source providing a new sense of direction, but also as a source of meaning, alternative and new ways of thinking" (p.32). Redundancy helps create a "common cognitive framework" among employees, and therefore facilitates the transfer of tacit knowledge. "When members of the organization share overlapping information, someone can make sense when others try to articulate the knowledge" (p.32).

For Nonaka and Takeuchi, the collective knowledge production process is a creative and a cognitive process that continues as team members "think of the similarities among concepts and feel an imbalance, inconsistency, or contradiction in their associations, thus often leading to the discovery of new meaning or even to the formation of a new paradigm" (1995, p. 67). The iterative and cyclical process of knowledge production occurs in four phases: "Socialization, Externalization, Combination and Internalization" (SECI Model) (p.83).

In Figure 1.2, we can visualize the content and form of knowledge transfer in the construction of the collective knowledge model revised by Nonaka and Toyama (2003). This revised model adds two levels of "interconnection between agents and the structure makes the knowledge process to occur as a dynamic and inter-linked interaction from an individual-to-societal level" (ibid., p. 3)

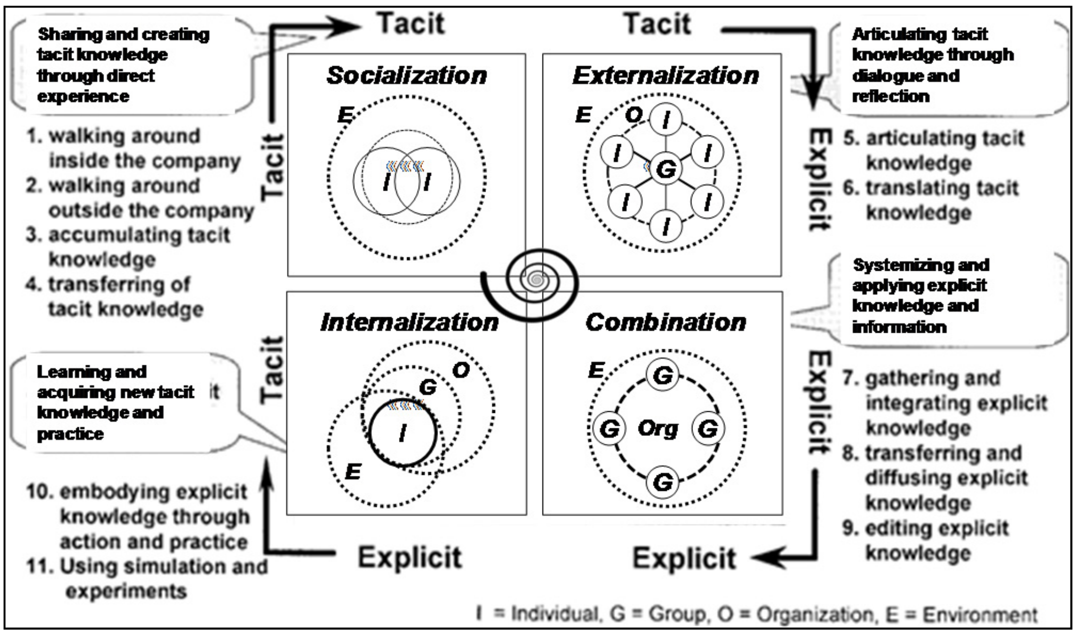


Figure 1.1 Knowledge production according to SECI Model
From Nonaka & Toyama (2003, p. 5).

### 1.4.3 Interactive Learning by Lundvall (2005)

The introduction of a new product in the market produced at once a new dynamic of knowledge acquisition. Thus, this dynamic also produces more exchanges of tacit knowledge between promoters or stakeholders, industrials, and users. In this dynamic context, Lundvall (2005) argues that knowledge is exchanged in two directions – toward the introduction of new products or goods, and toward producers, who also receive knowledge of laboratories or universities "as suppliers, in order to get updated on technological opportunities or even to buy R&D results" (idem).

This dynamic is defined by Lundvall as "interactive learning". This kind of learning defines a bidirectional interaction that demonstrates a creative collaboration. Collaboration must involve all participants in an innovation dynamic. Lundvall (2005) argues that the transaction costs of such kinds of collaboration are reduced for the transparency of exchanges between actors as "economic agents". Also, this collaboration is beneficial for the use of Information and Communication Technologies, because ICT generate a new communication scenario among designers, producers and users of technology. In this scenario, a closer, fairer and more sustainable relationship will be set (ibid). We therefore ask the question: what is the role of ICT in terms of enhancing collaboration for innovative enterprises? We will respond to this question in Section 1.5, which introduces the role of ICT for collaborative processes.

### 1.4.4 Systematic approach of innovation by Esser et al. (1996)

Esser, Hillebrand, Messner & Meyer-Stamer (1996) proposed a model based on a systemic competitiveness. In this approach, innovation is driven by knowledge flow and the collaboration links between enterprise stakeholders and society at different levels. A product of design is the result of the system dynamics as seen in Table 1.3. This dynamic can be observed in two scenarios. In the first one, the creative process is led by R&D-intensive enterprises. In the second, R&D enterprises provide new knowledge through the introduction of new product ideas for manufacturing enterprises. For Esser et al. (1996), there are four levels related to the innovation dynamics:

1) ***Micro-level***, i.e., the types of communications used to produce knowledge and ideas from these companies.
2) ***Meso level*** at which we review global enterprise needs, especially in relation to their networking and the collaboration activities.
3) ***Meta structural***, more based in the cognitive aspects and the professional skills and competencies crucial to effective inter-firm collaboration.
4) ***Macro level*** based in how the macro policy affects the inner innovation. In our case, Canada's National System of Innovation. This level is outside of the conceptual limits of this thesis, mainly because they are well documented and the proposed macro-

system is homogeneous for all developed countries that subscribe to the OECD innovation implementation guidelines and policies.

Table 1.3 Description of the systemic approach to innovation
Adapted from Esser et al. (1996), Láscaris-Comneno (2002), Jimenez-Narváez (2005), and Meyer-Stamer (2005)

| Level | Participants or managers | Definition (Meyer-Stamer, 2005, pp. 29-30) | Conditions | Functions |
|---|---|---|---|---|
| **Micro** | Enterprise | "The competitiveness of firms is strengthened by **integrating them in technological networks** (with other firms and research and technology institutions)." | Horizontal relationships. Individual in process of permanent learning. | Knowledge generation and assimilation |
| **Meso** | Networking | **"Technology policy** aims above all in the direction of a broad diffusion of new technical processes and organizational concepts and in this way encourages a continuous industrial modernization process". | Grouping for knowledge production in an industrial sector or cluster | |
| **Meta** | Individual - cognition and behavior<br>General idiosyncrasy | **"Socio-cultural factors and shared values**. These are, for example, essential in determining whether in a society the development of entrepreneurial dynamics are stimulated or discouraged." | Creative societal activities and social regulation | Creating social capital empowering the other levels |
| **Macro** | The State and policy control | **"Trade policy** encourages an active integration into the world market." | Definition of policies and infrastructure for innovation | Legislative structure for the national innovation system |

### 1.4.5 *Creative Zone* by Amesse & Cohendet (2001)

Generally speaking, knowledge transfer can also be defined by a model of collaboration and assistance to enterprise providers. In this case, Amesse & Cohendet (2001) explain that the collaboration relationship helps improve the quality of products in different ways, and that "the firm provides assistance to its suppliers not only in the areas of quality, cost reduction, factory layout and inventory management, but also in terms of increasing technological competencies and research facilities" (p. 1470).

Finally, this constant sharing dynamics produces a “***creative zone***”, in which “[…] creative ideas are essentially transferred through multiple functional interfaces (manufacturing to manufacturing, engineering to engineering, etc.)” (idem). Amesse & Cohendet (2001) define this creative zone as the where the ideas that begin the process of shared knowledge and technology transfer are born. This zone is the particular context in which engineering problems occur. This social dynamic is supported by three aspects: creative thinking, reasoning, (ibid), and knowledge management (Xu *et al.*, 2011).

Amesse & Cohendet (2001) propose some necessary factors that facilitate collaboration in this creative area:
- Development of benchmarking team capabilities
- Investment in the sharing of knowledge between the firm’s routines
- Regular socialization
- Acquisitions and trade with competing firms.

Activities in the creative zone have a “strong collective dimension”, building “common knowledge” (Cohendet and Meyer-Krahmer, 2001). Hayek (1975 cited by Cohendet & Meyer-Krahmer, 2001) talks of “[…] socially the dispersed forms of individual knowledge”. These authors highlight the notion that knowledge production needs a collective construction process based on individual inputs. “Social processes contribute to shaping the way knowledge is produced and circulates. In particular, the codification process takes place within specific communities, where the models, languages and messages are built by agents sharing a common understanding” (ibid, p. 1566).

Following in the next subsections, we present two business models related with the new vision of innovation. These models underline the fact that enterprises requiring the interaction among their own creative resources and the external context to increase the probabilities of achieving an innovation.

### 1.4.6 Collective Invention and Open Innovation

The concept of open innovation is not new. In the sixties, Allen (1979) discovered how the market includes elements to push up the challenge at different levels. Allen (1979) calls that phenomenon "Collective invention", in the sense of all involved participants in an industrial sector influencing the introduction of a challenge or the design of a new product development. This model corresponds to a social comprehension of the introduction of a challenge. Similarly, Chesbrough (2006) introduces "the Open Innovation" concept. His proposal is more of a "business model" because the innovation phenomenon opens doors to direct the market and the enterprise's production conditions. Chesbrough (2006) mentions that a business model has two functions: it "creates value and captures a portion of that value" (p. 3). These functions are reflected in an ***open model***, where we find different conditions of the ***closed model*** (inside the R&D process) when the enterprise works alone in the innovation process; between the conditions, "open models create value by leveraging many more ideas, due to their inclusion of a variety of external concepts" (idem). Also, in an Open innovation model, "where useful knowledge is widespread, there are many companies with many potential ways of using new technology, and many potential technologies that might be utilized in a company's business model" (ibid, p. 55).

In the Chesbrough approach, ideas are not well developed for external reasons to the enterprise or market. Sometimes, the intermediate markets[2] do not have any potential economic interest in the development of a new product, or the industrial sector is not efficient in the introduction of new technologies. These external conditions can be surpassed, becoming more "open" to new ideas coming from the market. In other cases, the companies "deploy certain internal technologies and commercialize them, while leaving a larger set of internal ideas and technologies unutilized" (ibid, p. 26). The unused ideas that are inside and outside

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[2] Ashish Arora and his colleagues (in Chesbrough, 2006) describe as 'intermediate markets" or markets of innovation, "a market that emerges after the creation of a new technology, before that technology has been sold. In this intermediate market, ideas and technologies are developed by sellers and sold by consumers" (p. 55)

the enterprise could be an important source of innovation. For the outside-inside direction, the enterprise can directly observe market needs, and for the inside-outside direction, unused ideas also "will generate new knowledge about the market and technical opportunities – which would never emerge if these ideas were kept bottled up inside the firm" (idem).

### 1.4.7 Co-creation of Value through Global Networks by Prahalad & Krishnan (2008)

For Prahalad and Krishnan (2008), innovation today is possible, and can lead to a fundamental transformation in the way business is done. Presently, ICTs have changed the nature of value creation in a new product or in a new service, especially by "digitalization, ubiquitous connectivity and globalization" (Ibid, p. 12). In contrast with Ford's "T Model", where consumers were "treated as an undifferentiated group", the Prahalad and Krishnan proposal follows the N=1 and R=G model of value creation. In this model, new ICTs allow the creation of a "unique, personalized consumer experience. [...] *The focus is on the centrality of the individual,*" where N=1 (one consumer experience at a time) "even if [an enterprise] serves 100 million consumers" (p. 11). This is possible because ICTs enable access to a wide variety of resources, a "global ecosystem," since "no firm is big enough in scope and size to satisfy the experience of one consumer at a time" (idem). In this second statement, "*the focus is on access to resources, not ownership of resources*", where R=G (resources from multiple vendors, and often from around the globe) (idem).

$$N=1 \text{ and } R=G \qquad (1.1)$$

*Co-creation Value*

This new relationship between consumer experience and resources overcomes the traditional model of selling products, and shifts to an "*ongoing relationship*", based on continuous feedback between the consumer and the enterprise. Innovation is produced by introducing new products or new services using detailed data obtained from individual experience and introducing this data into the research and development process. In other cases, the new service adapted for one consumer aggregates a new value for others, and so this process generates a value co-creation cycle.

## 1.5 Innovation theoretical models revisited

In the preceding subsections, we considered eight innovation models to observe the critical issues that can be summed up to define an innovative context. These issues are summarized in Table 1.4, to establishing complementary activities related to collaboration, social interaction among participants and the influence of ICT on the process. Indeed, the models are presented separately; they illustrate how those innovation activities “occur through the daily interactions and practices distributed communities” (Amin and Cohendet, 2004, p. 73). While for Nonaka & Takeuchi (1995), the knowledge production is obtained by the socialization from tacit to explicit knowledge (SECI model), for Lundvall, Esser et al., and Amesse & Cohendet, it is the social interaction that produces the interactive dynamic of innovation. In the case of Open Innovation, the social interaction increases the possibility of innovating (Chesbrough, 2006). Prahalad and Krishnan (2008) aggregate another dimension based on the use of global resources, especially ICTs that allow the exchange of knowledge among consumers and firms. For today’s enterprises, it is not important to own resources, it is more important to have access to the knowledge and the experience of users.

As shown in Table 1.4, the analysis of the models shows other factors supporting knowledge production and the introduction of new ideas. First, all models reveal how the innovation process is a social activity with a strong ***collaboration*** among several actors, as Cohendet and Meyer-Krahmer (2001) mentioned as “strong collective dimension”, collaboration makes possible building a cognitive space (Creative Zone of Amesse and Cohendet, 2001). Consequently, in the second factor: ***social interaction***, the ideas production process requires social dynamics based on strategies and methods that intentionally drive the individual process to a collective purpose, as the Open Innovation model proposed by Chesbourgh (2006), in which the ideas flow in a new social dynamic building new relations between technological agents. This interaction demonstrates an advantageous way to introduce ideas into technology and the market with a free sharing of ideas and knowledge, providing possible greater benefits for small enterprises and new technology sectors. The introduction of the new knowledge cannot be isolated from the context, according to cultural patterns (as seen at the Meta and Macro levels in the Esser et al. model). Finally, the third factor, the ***support of ICTs*** or the infra-structures (as proposed by Lundvall) and the access (Prahalad and Krishnan, 2008) may very easily support the human communication that is necessary for knowledge sharing. Prahalad and Krishnan (2008) demonstrate the influence of ICTs on the new collaboration model in fulfilling innovation, because ICTs enable the meeting point for the distributed actors bringing a multiple resources of information.

Table 1.4 Summary of Innovation Models Revision

| | **Essential knowledge production elements by Model** | | | |
|---|---|---|---|---|
| **Innovation Models** | **Knowledge Object of innovation** | **Collaboration** | **Social interac-tion** | **Importance of ICT or media support** |
| SECI Model (Nonaka & Takeuchi, 2003) | Transformation of tacit into explicit knowledge | ✓ | ✓ | × |
| Interactive Learning (Lundvall, 2005) | Process of learning (Knowledge exchange) | ✓ | ✓ | ✓✓✓ |
| Amin & Cohendet, 2000 | Science-based | ✓ | × | × |
| Creative Zone (Amesse & Cohendet, 2001) | Ideas production in a common space | ✓ | ✓ | × |
| Systemic Innovation (Esser et al., 1996) | Knowledge production by social level | ✓ | ✓ | × |
| Collective Invention (Allen, 1979 ) | Market standardization | ✓ | ✓ | × |
| Open Innovation (Chesbourg, 2006) | Market influence | ✓ | ✓ | ✓✓ |
| Co-creation of Value (Prahalad, 2008) | Value co-creation cycle | ✓ | ✓ | ✓✓✓ |
| **Convention:** ✓= mention × = non-mention | | | | |

## 1.6 Creative Collaboration in early design stages: ideas and knowledge sharing

Now that we have completed our review of innovation models, we introduce the term *creative collaboration*. Collaboration is the core focus of the teamwork. A collaborative task is the result of sharing all the available resources to end a collective task, and often, "the task is only achievable when the collective resources are assembled. Contributions to the work are negotiated and mediated through communications and sharing of knowledge" (Lang, Dickinson and Buchal, 2002, p. 90). The concept of collaboration is very broad; its definition depends on the context of work with semantic interpretations (Balmisse, 2002, p. 186). Termium Plus (Bureau Translation Canada, 2011), presents the words *cooperation, collaboration, partnership* and *association* as synonymous. Collaboration means: "the agreement between two or more parties, which have agreed to work together in the pursuit of objectives shared or compatible, agreement in which there are: sharing of powers and responsibilities (for example, for the provision of programs and services, the realization of data actions or policy); joint investment of resources (time, work, funding, equipment, expertise, information); shared responsibilities and risks; and, ideally, the common benefits" (idem). Talking about collaboration, there is no significant difference between teamwork and workgroup activities. Collaboration is "an activity where a broad task is achieved by a team" (Lang, Dickinson and Buchal, 2002, p. 90). Thus, Lang and others point out that effective collaboration requires harmony among several elements: "cognitive synchronization/reconciliation, developing shared meaning, developing shared memories, negotiation, communication of data, knowledge, information, planning of activities, tasks, methodologies, management of tasks" (idem). The collaboration could be described by two aspects: the characteristics of their activities, particularly the distribution among agents and the needed support that is object, often referred as –eCollaboration, these two definitions are described as following:

### 1.6.1 Distributed creative collaboration

In the innovation process, the need for collective interaction to resolve complex problems is evident. A design team works on finding a solution for a complex problem by sharing ideas, discussions, experiences and reflections. However, what exactly is creative collaboration?

We argue that the answer can be defined in two directions: 1) the concept of ideas sharing among teammates (when one produces an idea to communicate to another one) and 2) the whole process of sharing with everyone, collectively, such as the concept outlined in innovation models centered on the collective dynamic of contributions sharing. In the industry, a R&D team must make forecasts extending to more than 5 to 6 years into the future life cycle of a new product. They must also integrate new user needs and technological changes. It is a genuine challenge for organizations to capitalize on these knowledge sources by trying *to predict how the new product will perform in an unknown context*. From the social perspective, the challenge consists in sharing knowledge and interconnecting the people that are imagining these future conditions. Although forecasting may appear to be easy, generating the dynamic to define a new product in a team requires the synchronization of different interests and points of view among R&D teammates.

Table 1.5 shows the study conducted by Ulrich and Eppinger (2008) on the development of a new product which demonstrated that product complexity (number of pieces), organization team size (number of members involved in R&D) and the time of development are all correlated. For a simple new product such as a screwdriver, at least three people are needed in the in-house team and three on the external R&D team (Ulrich and Eppinger, 2008). In a more complex product, such as a Boeing 777 aircraft, the internal design team is made up of 6,800 people and the external team and service suppliers consist of up to 10,000 people. We can deduce that there also exists an interaction between different disciplinary knowledge fields, and as a result, the contributions of each participant are interconnected. The data of Table 1.5 also shows the relationships between the size of design teams, and variables such as product complexity, the number of parts and the life cycle of a product, development time, sales lifetime, production investment and the sales price.

### 1.6.2 eCollaboration: supporting collaboration by ICTs

The term *collaboration* was disseminated through the use of ICTs on all activities supported by collaborative digital networks (Terveen and Hill, 1998). *Digital collaboration* or *e-*

*collaboration* (Kock and Nosek, 2005) refer to various collaborative arrangements; from one that started quietly with the exchange of files, e-mails, or messages from text to better equipped collaboration, such as in e-rooms, conference Web groupware or information sharing portals such as SharePoint or Intranet portals within companies. E-collaboration is "collaboration among individuals engaged in a common task using electronic technologies" (Cited Kock et al, 2001 by Kock and Nosek, 2005, p. 1). ***E-Collaboration*** is also related to the area of technological tools, and thus to work conducted as part of activities supporting group initiatives: groupware (or *collecticiels* in French), and the "Computer Supported Collaborative Work (CSCW)" field of knowledge. The CSCW is defined as "the study of how people use technology, with respect to hardware and software, to work together in shared time and space" (Rama and Bishop, 2006, p. 198). In this thesis, we use the term *creative collaboration* for co-localized and delocalized work, and it is essential to understand the collaboration taking place within a techno-social dynamic directed by ICT. We will also study whether the use of different support technologies produces a distributed effect in co-localized teams, which is then explained at Chapters 3 and 4.

Table 1.5 New Product resources comparison
From Ulrich and Eppinger (2008, p. 5)

| **Product Development Needs** | **Stanley Tools** | **Rollerblade** | **Hewlett-Packard** | **Volkswagen** | **Boeing** |
|---|---|---|---|---|---|
| | Jobmaster | In-Line | Deskjet | New Beetle | Boeing 777 |
| | **Screwdriver** | **Skates** | **Printer** | **Automobile** | **Airplane** |
| **Annual production volume (units/year)** | 100,000 | 100,000 | 4 millon | 100,000 | 50 |
| **Sales lifetime** | 40 years | 3 years | 2 years | 6 years | 30 years |
| **Sales price** | $6 | $200 | $130 | $20,000 | $200 million |
| **Number of unique parts (part numbers)** | 3 parts | 35 parts | 200 parts | 10.000 parts | 130.000 parts |
| **Development time** | 1 years | 2 years | 1.5 years | 3.5 years | 4.5 years |
| **Internal development team (peak size)** | 3 people | 5 people | 100 people | 800 people | 6.800 people |
| **External development team (peak size)** | 3 people | 10 people | 75 people | 800 people | 10.000 people |
| **Development cost** | $150,000 | $750,000 | $50 million | $400 million | $3 billion |
| **Production investment** | $150,000 | $1 million | $25 million | $500 million | $3 billion |

## 1.7 Summary

To summarize, we can view creative collaboration as a distributed process of sharing, and not just the exchange of an idea or information or knowledge in itself. For the design of the platform, we have to offer a common cognitive space (cognitive field) that allows the team a confluence in time to share the knowledge objects. In this Chapter was identifying the main knowledge objects:

1) Information input: needs, expectations, dreams, insights
2) Problem definition: abstraction of information to define the new product/new service
3) Defining requirements: defining the criteria based on initial inputs
4) Idea proposal: possible ideas that could solve the problem
5) Idea elaboration: representation of ideas with details to be realized in a real situation
6) Interactive evaluation: each new element added is assessed to satisfy each criterion

Reviewing the innovation models, we observe the mention of four fundamental activities to innovation: knowledge production among individual and its environment (Nonaka & Takeuchi, 1995), limiting a social creative zone (Amesse and Cohendet, 2001) as a common space to exchange ideas and knowledge, possibility to exchange the new knowledge (ideas) in an interactive manner (interactive learning of Lundvall, 2005), and the co-creation model harnessed by the use of ICTs, which makes possible the interaction in real-time of N users in a large R=resources (Prahalad, 2008). These models enable understand the role of ICT as support for innovation activities: 1) the expansion of the creative space for R&D teams because it is easier adding new users and provide more resources of knowledge, and 2) The time reduction of product conceptualization when the community: experts, market, interact and provide information during the new product development. Due to its natural characteristics, the creative collaboration is distributed among several actors, in the design of platform; a prime factor to be considered is how ICT tools could support the creative tasks executed by the teams, as we will see in Chapter 4. And also, how ICT provide the support for capturing knowledge needed by the creative teams in a Knowledge Management System (techno-social system), as we will see in Chapters 5 and 6.

# CHAPTER 2

# CONTEXT OF COLLABORATIVE NETWORKING FOR INNOVATION AMONG R&D FIRMS: ANALYSIS OF CANADIAN STATISTICS

This chapter presents a descriptive and analytical study of knowledge flow in innovation and collaboration among innovative R&D enterprises. This analysis focuses on a model of collaboration, based in the data mining of the Innovation and Businesses Survey (Statistics Canada, 2005; 2008; 2010). The firms analyzed were innovator enterprises specialized in engineering and design in Canada presented in the paper Jiménez-Narvaez and Gardoni (2012). This data analysis allows the determination of:

- Some characteristics and the context of R&D enterprises
- Flow of knowledge and sources of innovation
- Activities to collaborate (tasks)

This theoretical data was contrasted with the needs of creative teams in 24 hours of innovation (Chapter 4), to propose a model of collaboration, as presented in Chapter 5.

## 2.1 Nature of R&D teams and enterprises

In Canada, design service enterprises are mostly small- to medium-size businesses. Zeman's study (2001) on this sector shows that although they are highly dynamic, these enterprises have these characteristics:

- Small-medium size (5 employees in average – 87% of total and earn 40% of sector income)
- Active and flexible – high staff turnover
- High sensitive to the demand of service of economic cycles (depended of project's demand)
- One or two autonomous workers – freelancers, consultants.

According with “Business, consumer and property services” survey from Statistics Canada (2010b) they were increased by more of 50% in average, in a growth rate of:

- Engineering services 73% (from 16,330 units in 1999 to 22,249)
- Architectural services 57% (from 7,327 units to 12,722)
- Design services 45% (from 6,774 units to 14,959)

In the dynamic of innovation, R&D enterprises present a behavior “more inventive than innovative” (Lonmo, 2007), because R&D teams collaborate with manufacturers or producers in developing new projects, but R&D teams does not introduce the product into the market. For this reason, all high technological skills involved depend directly on hiring experts and in their relationship with the manufacturing sector. Without the expert skills of R&D employees, the success factors for achieving innovation efforts will not be possible (Work Foundation, 2007). This expert knowledge and professional integration may also be achieved involving in a continuous learning process and co-design practices among experts and enterprises within their partners (Lundvall, 2005).

## 2.2 Sources of collaboration for R&D enterprises (Collaborative exchanges)

As Figure 2.1 shows, the innovation based-knowledge network of these enterprises is comprised of hired skilled workers, and brings together experts in teams with different skills. R&D teams are independent and obtain free association, which facilitates knowledge exchange for their innovative activities. Further, R&D teams report that the implementation of ICTs is also a source of innovation (as we will see in this thesis, ICTs do not constitute a strategy in themselves, but rather, accompany the free sharing of knowledge).

Networking details are shown in Figure 2.2, which presents the percentage summary of the professional interactions of engineering, industrial design and scientific services, and classify the importance of information provided by each stakeholder, ranging from high to low significance. In the figure, we observe mainly collaborators and the actions involved at the internal and external networking levels; at the internal level, we observe R&D internal staff, sales and marketing staff, production staff, and management staff. At the external networking level, we find suppliers of software, hardware suppliers, materials or equipment, customers, consulting companies, competitors and other companies in the sector, universities or other higher education institutions, professional conferences, meetings, regular publications, participation in fairs and exhibitions, professional associations and the Internet, and exchange providers.

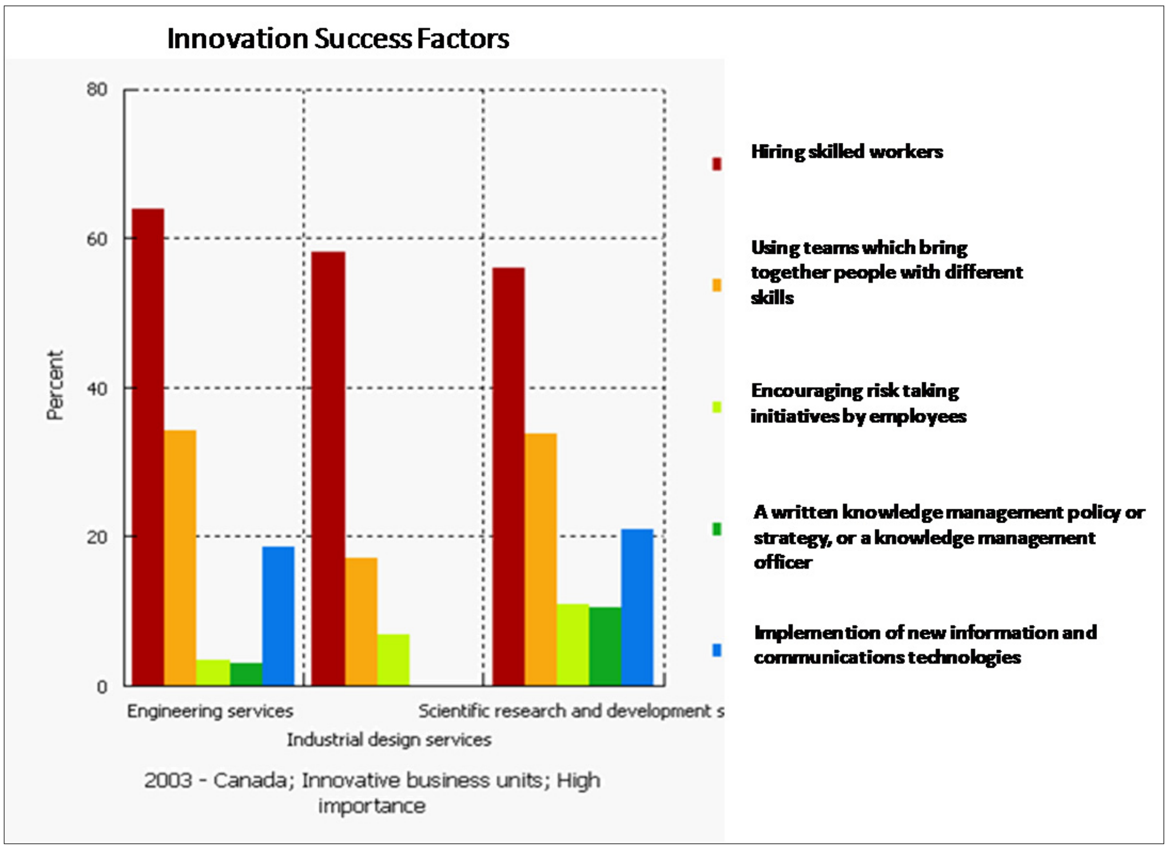



Figure 2.1 Sources of information for innovation in R&D enterprises in Canada from the *Survey of innovation, selected service industries, innovative business units using sources of information needed for contributing to the development of innovation* (Statistics Canada, accessed: September 7, 2010).

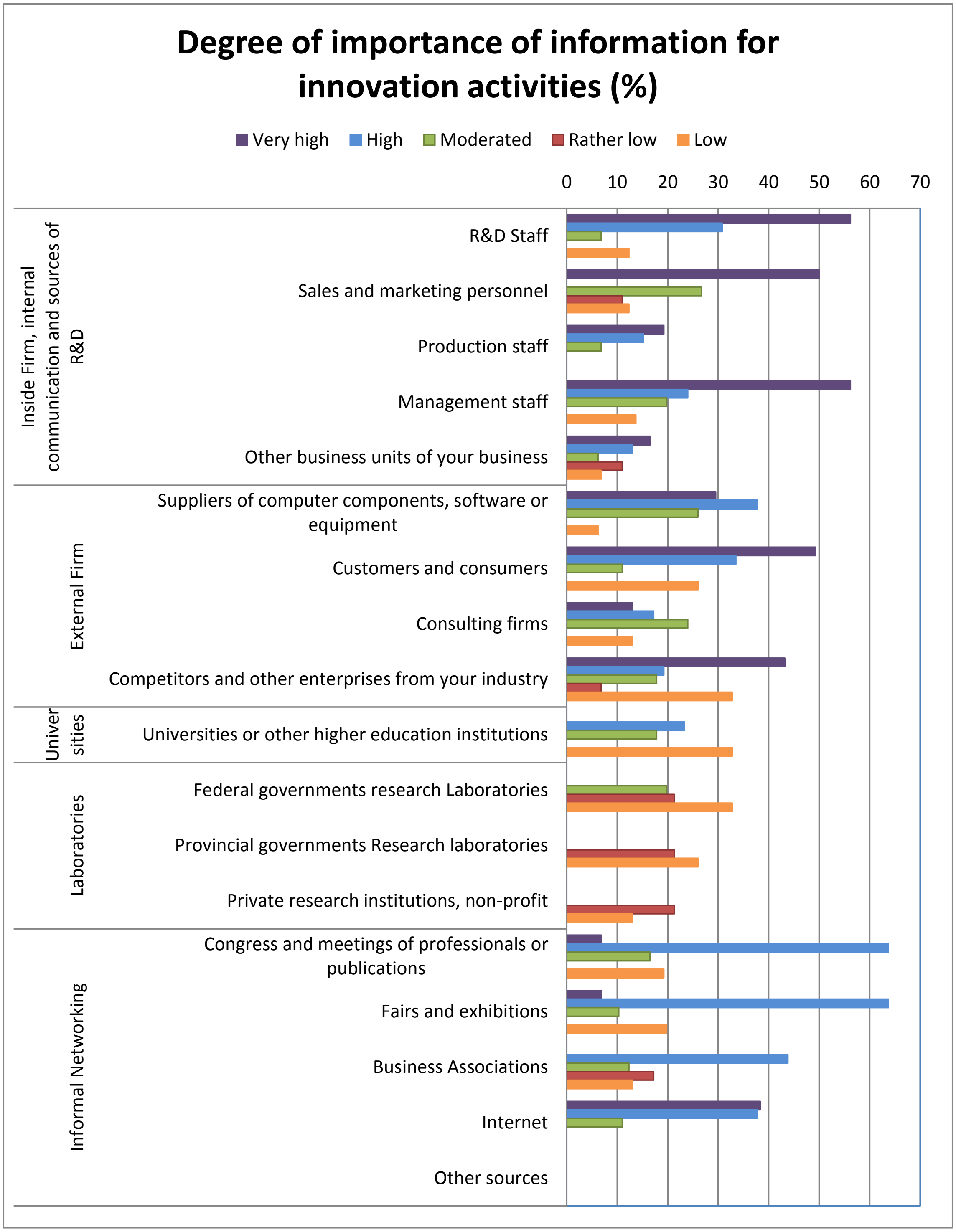


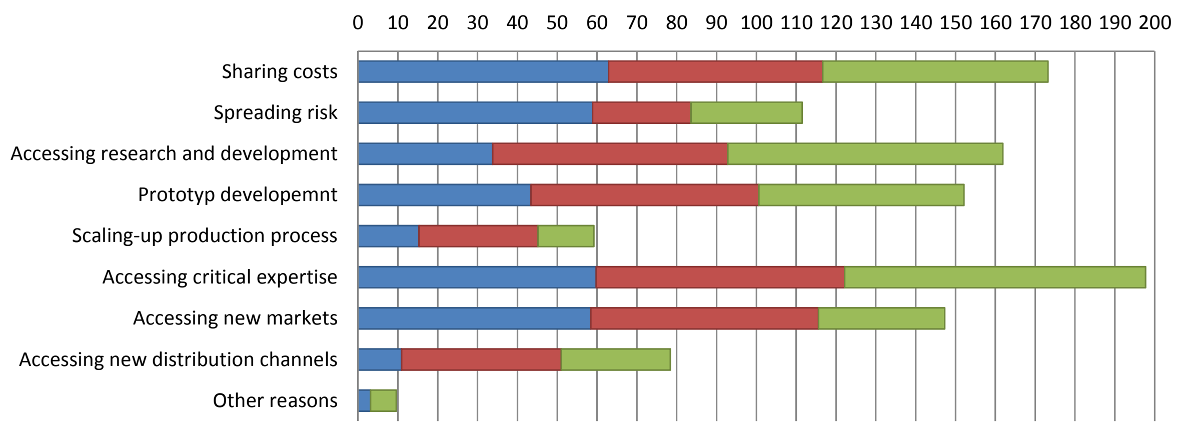

Figure 2.2 Importance of information sources for innovation activities of R&D SMEs.

*Survey of innovation, selected service industries, innovative business units using sources of information needed for suggesting or contributing to the development of innovation* (Statistics Canada, accessed: September 7, 2010).

### 2.2.1 Embedded Knowledge: experts, expert thinking and informal collaborative network

Expert knowledge is the main creative output of R&D enterprises, according to Canadian statistics and to a report by the Department for Culture, Media and Sport of Great Britain (Work Foundation, 2007). The expert in a given subject matter or in the R&D domain is a key player in R&D activities. The English report cited above (ibid) mentions that the main reason for collaborating with these enterprises is to obtain access to ***expert thinking.*** In this regard, we observe a type of approach to knowledge whose point of departure is based on the "translation of expert thinking" into a creative output when the expert integrates a change directly into the products (idem).

Figure 2.3 shows the exchanges needed to achieve innovation. Access to expert thinking is one of the main reasons for collaborating with these R&D enterprises: on average, 66% of respondents state that having access to critical expertise as a main reason to collaborate. We also highlight other reasons behind collaboration, including the sharing of the high costs of R&D activities (58%), improved access to R&D (54%), development of prototypes (51%), access to new markets (extension to other localities) (49%), risk sharing (especially in the case of engineering companies) (37%), access to new distribution channels (26%), and increased scale of operations (20%). In addition, these enterprises generate an "***informal networking***" with their Associations, Internet and business community of knowledge identified in Figure 2.2, we notice that collaboration activities among experts are indispensable for innovation; this illustrates the importance of activities related to the strategic development of business operations – a model of "***shared expertise***", that is, "proprietary knowledge assets that are exclusively held by knowledge workers and shared in their work or embedded in technology (Wiig, 2004 cited by Dalkir, 2012, p. 79). Collaboration is the center of knowledge transfer because it enhances the "collective nature of knowledge production, distribution and use" (Cohendet and Meyer-Krahmer, 2001, p. 1566). This evidence allows us to describe that the core process that occurs in knowledge flow design is related to the support of the sharing of the embedded knowledge of "experts".




| | Other reasons | Accessing new distribution channels | Accessing new markets | Accessing critical expertise | Scaling-up production process | Prototyp developem nt | Accessing research and developme nt | Spreading risk | Sharing costs |
|---|---|---|---|---|---|---|---|---|---|
| Engineering | 3 | 11 | 58 | 60 | 15 | 43 | 34 | 59 | 63 |
| Industrial Design | 0 | 40 | 57 | 62 | 30 | 57 | 59 | 25 | 54 |
| Scientific | 7 | 27 | 32 | 76 | 14 | 52 | 69 | 28 | 57 |
| Average | 3 | 26 | 49 | 66 | 20 | 51 | 54 | 37 | 58 |

Figure 2.3 Average of reasons for collaboration (%) by SMEs in R&D

On the other hand, the type of integration of technical knowledge – operational, tactical, and strategic activities – involves a complex cycle of negotiation activities (ibid, p. 17). Figure 2.4 shows a description of this knowledge flow process in the immediate environment of Canadian R&D enterprises. In collaboration networking, information sharing flows informally between all the system's actors, and the link between consumers, communities and suppliers is not that obvious. The model of collaboration shows that each project or each idea to develop had a specific time frame. We would also like to note that perhaps the most important aspect consists of the skills involved in capturing the knowledge of in-house and outside experts. This integration of new knowledge may possibly nourish the evolution of R&D projects.

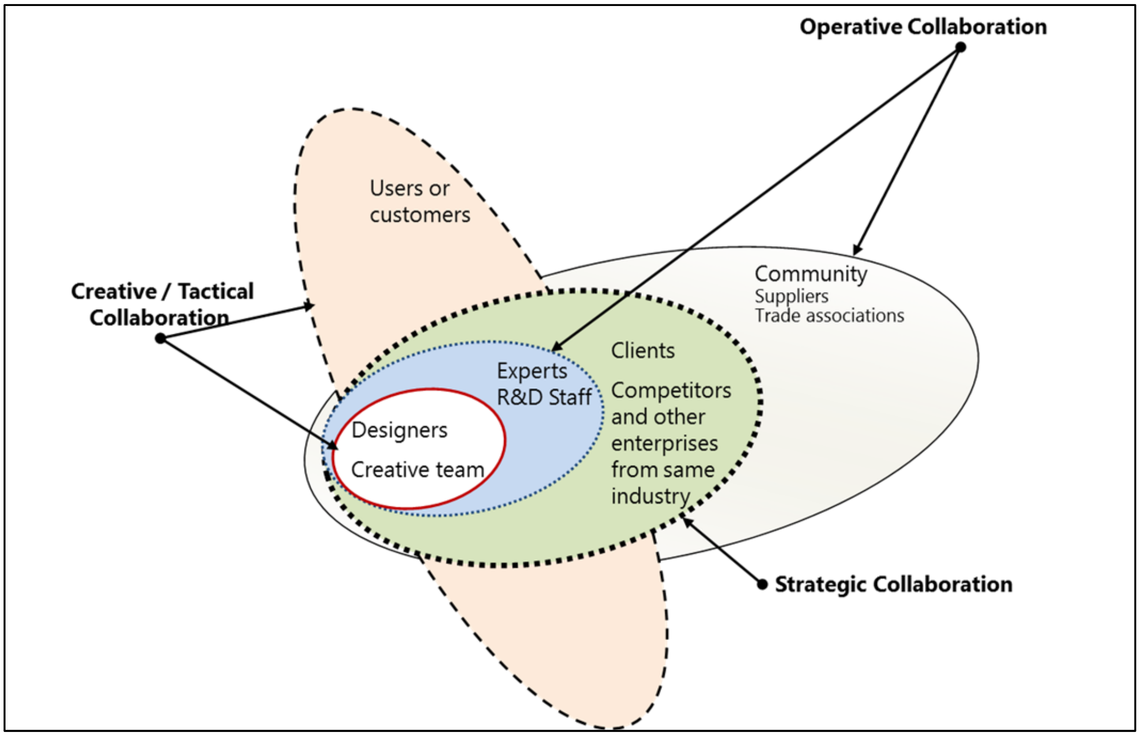



Figure 2.4 Model of collaboration networking between creative R&D teams

## 2.3 Task flow of Knowledge Sharing: Strategic, Tactical and Operative knowledge

Analyzing collaborative exchanges among R&D teams and their context by the task flow analysis method (Dalkir, 2012, p. 200) enables us to observe that they are guided by a decomposition of activities aimed at promoting the innovative collaboration seen in Section 2.1 (Figure 2.2). This exchange is related with three competencies: ***strategic, tactical and operational competencies*** (Anthony, 1965). Recently, Genin, Lamouri and Thomas (2005), in the French standard AG5115 (Association française de normalisation)., analyzed these comptencies, which also are related to the task classification, the client and product relationship, and the execution time. These task taxonomies are summarized in Table 2.1, in which is presented a proposal of the taxonomy of collaborative activities based on tactical, operational and strategic collaboration. At the strategic and tactical levels, we find “the skills necessary to integrate and apply competencies” (Dalkir, 2012, p. 200). We distinguish these activities as central to trade between R&D teams.

Table 2.1 Decomposition of innovation activities
Adapted from French standard AG5115 (Genin, et al., 2005)

| | **Innovation task by competencies** | | |
|---|---|---|---|
| **Criteria** | **Strategic** | **Tactical** | **Operational** |
| **Subject** | Logistic chain | Use of resources | Use of materials and orders |
| **Objective** | Access to markets | Profitability and optimization | Reaching tactical decisions |
| **Role** | Prospective | Agreement | Programming |
| **Indicator** | Market leader | Economic activities | Compliance rate |
| **Term** | Long | Medium | Quick reaction |
| **Product market** | Market satisfaction | Client satisfaction | Product satisfaction |

Amin and Cohendet (2004, p. 15) affirm that the transactional cost of codified knowledge is very high (explained section 1.4.1). In R&D creative teams the codified knowledge is obtained at the end of the process. This ***Operative Knowledge*** – is produced by the team members (experts involved in the project). However, the main knowledge exchange and plus complex for new product definition is proposed at the beginning of the new product design.

In this step: ***Strategic or Tactical Knowledge*** – is produced and available in a specific context (stakeholders and market). These blocks are qualitatively different, strategic-tactical tasks are related to the market, and prospective knowledge assumed by stakeholders or project partnerships and operative tasks is related to the performance of the team concerned, and to task assignment, elaboration and control. Otherwise, we may associate knowledge with the task outcome; operative tasks are presented through explicit knowledge –documents, drawings and presentations, while strategic-tactical tasks are associated with insights, knowledge expertise assumptions, and the outcome is tacit knowledge, which is also very difficult to express.

## 2.4 Knowledge transfer between Strategic and Operative Tasks

As seen in Figure 2.3 and Figure 2.5, we deduce an intrinsic complexity of accessing expert thinking and in the sharing of strategic and tactical knowledge, as it can be seen in Figure 2.5. Sharing ***operational tasks*** (the codified knowledge as the result of a collaborative process and expressed in models, technical plans or prototype implementation) is easier and less expensive than obtaining ***strategic tasks.*** In fact, the strategic knowledge (obtained accessing shared expertise and spreading risks) is significantly harder to acquire. Innovation and creative tasks in the strategic dimension is obtained by organizational competencies that are more difficult to develop.

| Reasons to collaborate | Operational | Tactical | Strategic |
|---|---|---|---|
| | | | Increasing complexity → |
| Sharing cost | | • | |
| Spreading risks | | | • |
| Accessing R&D | | | • |
| Prototype development | • | | |
| Scaling-up production process | | • | |
| Accessing critical expertise | | | ••• |
| Accessing new markets | | • | |
| Accessing new distribution channels | | • | |
| | Technical integration (Mainly objective) | | Negotiation (Mainly subjective) |

Figure 2.5 Analysis based on type of knowledge and complexity of the information exchanged

## 2.5 Summary

In this Chapter, we analyzed the context of R&D enterprises, particularly their need to obtain strategic knowledge from the external expertise and from an informal network. This network is supported by the Internet, association meetings, congresses and fair exhibitions. In innovation activities, we propose the use of an ***embedded knowledge*** because knowledge of innovation does not reside solely in books or business databases or research centers. More than anything, the knowledge required by innovation is a part and parcel of ***the critical expertise*** that surrounds the team.

In order to advance in collaborative projects, R&D teams must exchange the strategic knowledge that is obtained within shared expertise or accessing external expertise, sharing R&D knowledge of informal networking, and spreading risks among sponsors.

For the design of a collaborative Platform, we have to take into account the free-association dynamic among R&D team with their external partners. Thus, the platform has to provide a free-networking structure that enables informal and casual meetings. Also, it is necessary to support in the earlier process of design, in which R&D teams need strategic knowledge to conceptualize the new product. This conceptualization has to incorporate the tacit knowledge among the network (stakeholders, internal staff and external partners) and inside the creative team, as we will see in the rest of this thesis.

# CHAPTER 3

# PROBLEM STATEMENT, RESEARCH OBJECTIVES AND METHODOLOGY

This chapter presents the problem statement, the research proposal, and the methodology developed to design and test the collaborative platform that supports creative teams in R&D activities. We propose to analyze and test the performance of creative teams during "24 hours of Innovation", an international competition developed by ESTIA, and that has been organized each year since 2010 by our research group at École de technologie supérieure.

## 3.1 Problem-finding background

### 3.1.1 From tacit knowledge production to codified knowledge

In the Nonaka and Takeuchi (1995) model, new knowledge is obtained by the transformation of tacit knowledge into explicit/codified knowledge. These authors argue that the "knowledge encoding" process is important for the transfer of ideas, information and knowledge within organizations. However, codification is not a natural process for a creative team because the members exchange strategic knowledge tacitly. Forcing the transformation of knowledge objects from tacit knowledge into codified knowledge generates problems for the following reasons:

1) Tacit knowledge is created by cognitive and social dynamics, rather than by an imposed organizational methodology. Indeed, we cannot impose the sharing of new knowledge in a codified manner.

2) R&D teams follow a natural exchange of ideas informally; this interaction is rather tacit, fuzzy, and casual, particularly at early design stages.

3) The encoding process is less efficient when using ICTs that require the capture of data through forced encoding (typed text, written information or scanned images).

In early design stages, creative teams exchange tacit knowledge for strategic decisions. This dynamic is continual until the project definition, when ideas are finally explained in the form of codified knowledge. Quick codification is not possible during conceptualization, because the project becomes more complex when several solutions are proposed at the same time, or when several members are brought together, and when the research focuses on the most creative solutions or strategic levels (see Sections 3.3 and 3.4) in the ideas generation process. Tacit knowledge is more difficult to transfer among team members due to the fact that ideas have a new content, and have to be explained with analogies or metaphors (Nonaka and Takeuchi, 1995). On the other hand, tacit knowledge is also difficult to manage because it is distributed in a "multiplicity of activities that have to be developed in parallel, with various time delays, which need to be coordinated to lead to valid results; the difficulty in establishing goals and the precise characteristics from the beginning of a project, the goals and the precise characteristics of the research product, which are sometimes hardly measurable (for instance, unexpected wrong results could become good research products, which could be physical or conceptual)." (Gardoni, 2005, p. 137). In the next section, we present the problem associated with tacit knowledge sharing in detail.

### 3.1.2 Complexity of dissemination of the content of an idea through tacit knowledge

The content of the needed tacit knowledge to produce a new product is provided by:
1) The value chain of producers and the market: consumer expectations or complaints, distributors, sales information, and consumer's services.
2) Trends, forecasts and insights provided by the market or technological specialists. There should be an advance of more than two years for small products (e.g., electronic consumer products) and more than five years for larger products such as aircrafts (Ulrich and Eppinger, 2008), which presents difficulties forecasting the knowledge needed (see Table 1.5), and
3) The expert thinking (embedded knowledge) that identifies scientific and technological sources involved in the new product conceptualization.

For the development of new products, creative teams and partners must integrate the above aspects to conceptualize the new product. This conceptualization is a social process, also distributed over a long development period (as seen in Sections 1.6.1 and 2.4). If this variable time anticipation is not supported, the team could lose important information during that time. Further, there is no available "audit" of the knowledge needed by a team in order to define knowledge sources. Frappaolo (2006) proposes a "measure" based on the knowledge needs and knowledge sources effectively used by the team (in our study, a "needs" audit was realized, and will be presented in the next chapter).

### 3.1.3 Lack of a knowledge management system for a creative collaboration

In Section 1.2, we mentioned the existence of a *Design Rationale* Model. However, this model is not popularly used in design, because it can create tension between two complementary processes: the creative and structured thinking driving by Rationale Model (Carroll, 2010). The study of Wang, Farooq and Carroll (2010) explains that in some cases, designers feel that there is no place for creativity activities in a rational cognitive space, and in other cases, creative methodologies are ignored if the designer has not been introduced to creative methods previously, during his/her training process. According to Schuster et al. (2007) creative structured methodologies such as TRIZ and C-K will only be used if they are "embedded" in a professional practice during the designer's training program. As well, Trépanier and Gosselin (2007) argue that these methodologies are maintained if they are socially accepted and practiced within the organizational culture (Trépanier and Gosselin (2007). This analysis of the knowledge sharing and retrieval cycle in the design process leads us to conclude that creative outcomes such as ideas, opinions, and insights constitute tacit knowledge that has to be captured in a natural manner and induced by organizational culture. In Chapter 5, we will explore the paths that should be used to promote knowledge management activities among creative teams and their partners.

### 3.1.4 ICT impact on collaborative ideation process

Regarding the distribution of actors in the ideation process, ICTs become an invaluable resource for merging distributed tacit knowledge in an interactive dynamic (Crescent, 2007; Nielsen, 2012). ICTs allow stakeholders to be brought closer in knowledge sharing. However, the optimism accompanying ICT use can add other worries:

- The need for a continual learning process owing to the constant innovation of ICT tools, making it hard to introduce the same groupware or standard software in all enterprises, organizations and teams (Jiménez and Vargas, 2004)
- The time needed to implement ICTs, especially learning, availability of equipment and infrastructure, etc.
- The isolated or lonely behavior of Internet users
- Techno-economic factors (obsolescence due to frequent changes of operating systems, license expiration, hardware uselessness, etc).

However, countering the above-mentioned drawbacks, DiPietro (2012) argues that ICTs have a positive impact, especially Cloud-Computing Technologies or Social Media, for collaboration dynamics. Some basic theories of collaboration are based on new user behaviors following the implementation of Web 2.0[3] or Web 3.0[4]. By Web 2.0 collaborative technologies, we refer to applications that use the Internet more as a social network than as an informative infrastructure (Web 1.0 is based on plain text information). The new term Web 3.0 is already in definition, the new applications or platforms based on Web 3.0 technologies redefining the use of Internet. For Jiménez-Narváez, Segrera and Gardoni (2013), ICTs aggregate some opportunities for the collaborative process: "interconnection, an enhanced knowledge environment, interactivity, flexibility, storage of information, instantaneity, graphicability and social

[3] "Web 2.0 applications have spread rapidly and increased opportunities for working remotely at a dizzying pace. We can link this to the fact that some of them are available free of charge and that they are generally easy to use. In addition, these technologies have features that allow remote collaboration and users in different geographical areas can easily use (data available online, no software to install on the computer, etc.). It is enough to have access to the Internet" (O'Reilly, 2005)

[4] The term Web 3.0 is not yet defined with precision. It refers to all technologies that integrate the Semantic Web. Hendler (2009, pp. 111-113) defines Web 3.0 as "Semantic Web technologies integrated into, or powering, large-scale Web applications". Web 3.0 technologies have three common elements:
"- Creating tools that allow groups of users to create, share and evolve a new generation of open and interacting social machines,
- Creating the underlying architectural principles to guide the design and efficient engineering of new Web infrastructure components for a new generation of social software, and
- Extending the current Web infrastructure to provide mechanisms that make the social properties of information sharing explicit and that guarantee that the uses of this information conform to the relevant social policy expectations of the users" (Hendler et Berners-Lee, 2010, pp. 156-161).

interaction among the individual and collective work" (ibid). However, ICTs also present some limitations, such as: "redundancy, isolation, loss of connectivity, data obsolesce" (idem). We would like to highlight other obstacles to collaboration mediated by ICTs:

***The constant changes in ICTs exceed the required learning time.*** The constant evolution of tools and applications has transformed the Internet into a fruitful place for collaboration. However, there is a huge difference between the easy utilization of ICT technologies for collective work and a participation in networks, practicing communities, or groupware.

***A low participation in large networks.*** Despite the availability of platforms, most companies show little use of them for project development, and their effective participation and collaboration is very low (Hill et al., 1992; Terveen and Hill, 1998) and isolated (Nielsen, 2006). Nielsen (2006) proposes a 100-90-9 "Law of participation inequality" applicable to communities in networks. This law proposes that for 100 users, 90 observe, 9 contribute from time to time, and 1 contributes assiduously, the latter generally being the content owner. The consultant Levan (2009) argues that this law of inequality in participation decreases to a 92-7-1 proportion for business networks. Why is the participation rate so low? Nielsen (2006) explains that the dilution of collaboration depends on "the size of the group, the familiarity between the members and the interactive or conversational strategies" (ibid), and the organization and the methodology used to knit the community tightly. These conditions show that if the number of participants is high, it will be more difficult to coordinate their interests. We must therefore create a knowledge management structure to promote the use of the platform with social strategies for collective sharing, and for the training of future designers to work in collaborative mode (Benghozi et al., 2002).

***Spread utilization of ICT tools without an appropriated personalization.*** Balmisse (2004b) mentioned a phenomenon produced with the introduction of a new ICT. On the one hand, a new ICT is spread quickly, independently of its actual intended use. For example, an organization may limit knowledge sharing to just Wikis. A Wiki is not appropriate for all project development stages, because merely implementing one does not resolve project management needs. An ICT should not be transferred while only considering success on the Internet (Balmisse, 2004a); rather, they must be customized to meet the collaboration needs of each team, organization, or community. On the other hand, Balmisse (2004b) argues that there is a lag between the design of groupware and its use. This discrepancy is due mainly to the fact that ICT design is developed for professional or functional purposes, and not for a natural collaboration within teams, including temporal collaboration, collaboration by project, or collaboration by community of practitioners (Balmisse, 2004b, p. 25).

***Underutilization of most popular tools*** like "e-mail, wiki, groupware, co-design, instant messaging" (idem), or communication tools like Skype, GoogleChat, Talkatone, etc., which have free versions available for all users. This underutilization generates "a partial use of the collaborative possibilities" (idem), and generally, these simple tools are replaced by high cost systems that do not contribute a collaborative value to the team or the community. Consequently, groupware and networks obtained after paying elevated costs respond only partially to the multitude needs of R&D teams. On the other hand, R&D enterprises implement sophisticated groupware or CAD systems to develop products, but this technology does not resolve their collaborative project communication needs either in the strategic definition.

### 3.1.5 Impact of ICT on creative collaboration

One specific positive impact of ICTs on creative activities is its ability to facilitate the capture and the codification of the knowledge produced by team members. However, "knowledge capture cannot, therefore, be a purely mechanistic "add-on", because it has to do with the discovery, organization, and integration of knowledge into the fabric of the organization" (Dalkir, 2012, p. 99). Consequently, one important problem for creative teams is how to use ICT effectively to produce ideas. Studies on the use of ICT for the generation of ideas provide somewhat positive results. Cooper (2000) affirms that "computer-aided and non-computer tools and techniques can enhance the creativity of groups" (p. 253) because the team is encouraged to share in a free and transparent flow of information.

In this regard, Ocker et al. (1995) , comparing teams that use ICTs with those that do not, found that the quality of creative solutions is not lower in team supported by ICTs. They state: “the findings suggest that there is a positive relationship between distributed asynchronous communication and the quality of the solution, as groups in both CC [computer conferencing mode] conditions were rated higher than their face-to-face counterparts” (p. 11). This result is similar to the findings of Paulus (Kohn, Paulus and Choi, 2011; Paulus and Yang, 2000; Paulus et al., 2005; Paulus, Dzindolet and Kohn, 2012). The results indicate how the use of ICTs for team communication does not change creative behavior (Ocker *et al*., 1995). Furthermore, Ocker et al. (1995) demonstrate that teams that use ICTs can attain efficiency improvements when they “share the knowledge and skills, interact and reformulate appropriate scheduling strategies and interaction that integrates the coordination and effort of each member” (p. 6). Ocker and Fjermestad (2008) also noted the importance of generating collaborative work strategies, because teams that have had significant creative work, are those which are involved in: “more critical commentary and active debate, hallmarks of a climate for excellence”. In conclusion, the creative collaboration performance of a team depends more on how it interacts with others and the teamwork strategies used.

Ocker (2007) and Nemiro (1998) hold that the levels of creative performance and creative inhibitors are the same for teams with or without ICT support. Major inhibitors to creativity include remarkable factors such as “member dominance, technical and functional domain knowledge, focus on external reward, time pressure, downward norm setting, structured problem solving approach, technical difficulties, lack of a shared understanding, and non-stimulating team members” (p. 40). For Nemiro (1998), the factors that determine the levels of creative performance are “freedom in the initiative or proposal of new ideas, the perception that innovation is a desirable state for the organization, trust and tranquility in participation, diversity and the encouragement of creative tension, clarity in the definition of goals, challenges and vision” (pp. 39-41).

However, Nemiro (1998) considers that there are three conditions with a positive impact when a team uses ICT tools:

> "a) connection, the elements that need to be in place for a team to develop and maintain identity and a sense of community […Connection involves both task (dedication-commitment), (goal-clarity) and interpersonal (information sharing; personal bond; trust) connections…];
> b) raw materials, the basics on which virtual team members can draw in producing creative work; and,
> c) management and team member skills conducive to creativity [...] Once a connection between team members is established, team members need to be supplied with sufficient raw materials, both in terms of information, human and technological resources, and time, to accomplish the creative work" (p. 222).

Finally, if there is a good creative dynamic and enough motivation within the team, it will be reflected positively in an ICT environment. Some of these idea production aspects will be studied in more detail in Chapters 4 and 8.

### 3.2 Problem statement

In the early stage of product definition, when creative teams define the initial concept, the main strategic activities are mostly shared by tacit knowledge. At this stage, the tacit knowledge is very difficult to capture, because it is distributed among different actors and information resources. Particularly, knowledge production is "embedded" in expert thinking and in an informal networking. In addition, the formulation of the initial concept requires the formulation of a knowledge management system, which is not usually implemented by designers. This strategic process is not well supported by a knowledge management system, and not even by ICTs. ICTs are also distributed among participants and current ICT tools are not well-suited to process the tacit knowledge produced.

We propose this research to better understand and support idea and knowledge (creative collaboration) exchanges within creative teams in their respective direct context. The aim of this research is to support the creative teams through the design of a collaborative platform that allows users to share the tacit knowledge needed for innovative activities. We propose to test this ICT platform among the creative teams of "Les 24 heures de l'innovation", where sharing tacit knowledge in the context of creative collaboration is an established need.

Summarizing our problem statement, we observe that it is broken down into two dimensions:

***Theoretical dimension:*** Improving a knowledge management system for the exchange of tacit knowledge to support distributed creative collaboration.

***Practical and technological dimension:*** Developing and testing an ICT platform for creative teams based on a knowledge management system that supports creative collaboration.

These two dimensions synthesize our problem in a multi-disciplinary research work covering theoretical and technological issues. In the theoretical dimension, we focus on the improvement of the ICT environment for the exchange of knowledge to support informal exchanges in the early stages of product development. This dimension raises the importance of cross-sectional analysis of collaboration conditions through 1) the communication of ideas, 2) the analysis of the knowledge flow within and outside creative teams, and 3) the strategies required for acquiring knowledge from the context. The technological dimension will be focused on the design of specifications for a collaborative platform, to enhance the informal ideas exchanged among members and its surrounding context. In section 3.4, we define the objectives of this doctoral research.

## 3.3 Research question

For our research work, we define the following research question:

***How is it possible to support the distributed creative collaboration through a knowledge management system and a collaborative ICT platform for ideas and knowledge sharing?***

## 3.4 Research objectives

The aim of this thesis is to support the creative teams in the process of conceptualization of a new innovation-oriented product. Through this thesis, we will seek to:

- Determine the needs of creative teams during the conceptualization stage of a new product;
- Propose a Knowledge Management System (knowledge and tools) that enables the support of tacit knowledge produced in distributed condition of team members;
- Model a Platform that supports internal creative team's needs and the external context for innovation;
- Propose the assessment of the creative collaboration meaning the user experience testing and the realized task by creative teams on the ICT prototype.

## 3.5 Methodology

This research follows a "Research-oriented Design" methodology (Dalsgaard, 2010, p. 200), in which a "design situation", in our case the design of a collaborative platform, "is employed as a means of generating insights that will feed into the design of a product" (Idem). This methodology is also defined as "Research through Design"(Gliner and Morgan, 2000; Koskinen et al., 2011), in which the "design artifact became design exemplars, providing an appropriate conduit for research finding" (Zimmerman, Forlizzi and Evenson, 2007, p. 493). This methodology is particularly useful in the design of Human Computing Interfaces (HCI) that needs interactive research between technical opportunities and theory model gaps (ibid).

Figure 3.1 presents a general overview of this research that follows the steps:
1. The validation of data collected comparing the theoretical results (Chapter 2) with the needs and ideals mentioned by 24H teams (Chapter 4).
2. The design of a collaborative platform, combining main collaborative specifications and ideals reported by creative 24H teams: formalizing the information meaning UML Language (Chapter 5) and defining the specifications (cahier des charges) in Chapter 6. The modeling of Platform (ideality aspects) is realized proposing an analysis of state-of-art of existing ICTs and proposing new functionalities to foster creative collaboration.

3. The test of the collaborative platform is carried out implementing a prototype. This prototype is evaluated by four studies: 1) testing use cases (user-acceptance testing), 2) task analysis (Chapter 7), 3) the analysis of the performance, and 4) the usability test (Chapter 8).

In Figure 3.1, we observe the delimitation of the conceptual and the contextual framework of this research, it is necessary to analyze the objects of knowledge and the theoretical models of innovation (Chapter 1), and also the context of networking of R&D enterprises in Canada (Chapter 2). This theoretical data is validated with a detailed study of the internal tasks and activities that creative teams execute during a new product development (Chapter 4). Using these data, we can model the design of a collaborative platform, defining specifications and new functionalities (Chapter 5).

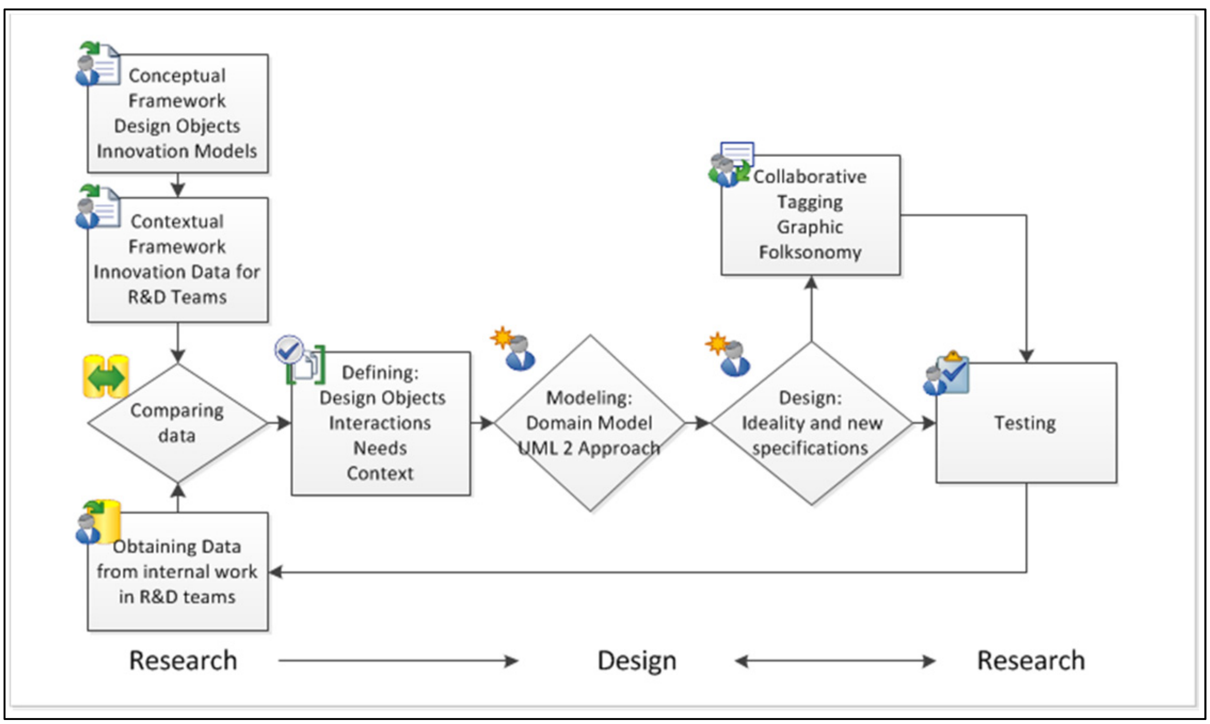



Figure 3.1 Thesis Research Framework

At beginning of this research, we tried to obtain the data directly from R&D SMEs. This information was not available, mainly because R&D teams did not agree to provide it (due to the fact that this information is its “core business” and they were uncomfortable sharing this sensible information, they were also concerned for intellectual property risk, a waste of time, or an intrusive action). As analyzed in Chapter 2, R&D enterprises are small size (5 to 10 employees), work in distributed and in an opportunistic manner (which means that they work when a new product is demanded by a client or a stakeholder). These enterprises show high similarities with the creative teams of “Les 24 heures de l’innovation”® (24H). 24H is an innovation competition created by the École Supérieure des Technologies Industrielles Avancées (ESTIA, France), in which participants are required to develop innovative solutions to real R&D problems over a 24-hour period. The international edition is organized by our research team at École de technologie supérieure. We decide to observe the 24H creative teams, because it provides a conceptual and practical basis for our research.

During this research, we observed a total of 242 creative teams, working in different editions of 24H; in this thesis are compiled the results obtained in November, 2011 and May, 2012. All the studies are summarized as follows:

1. May, 2010 – 5 teams (organized by ÉTS), observed each hour
2. October, 2010 - 27 teams (organized by ESTIA), observed each hour
3. May, 2011 – 35 teams (organized by ÉTS and using Teambox with the enterprise IODS), observed each hour
4. November, 2011 – 40 teams (organized by ÉTS and using InnoTiz with Mc Gill – ÉTS - Ethical Plan Certificate), observed each two hours
5. May, 2012 – 135 teams (organized by ÉTS and using InnoKiz with Mc Gill – ÉTS Ethical Plan Certificate), observed each three hours

Some of the reasons to have chosen the creative teams of 24H are:

- Drawing the context information for creative activities: contrasting the theoretical information of Chapter 1 and Chapter 2 with the knowledge objects exchanged by creative teams with their sponsors.

- Obtaining the data simultaneously, observing the needs and the performance of R&D (quantitative and qualitative analysis) of the creative team performance and the needs of R&D teams; in 24H, this information is accessible.
- Analyzing the particular interactions presented when teams utilize a collaborative knowledge/ideas sharing platform. 24H teams are available to test such platforms and tools, while R&D SMEs are not.
- 24H also establishes industrial context because big and medium size enterprises provide challenges in real-time conditions.

As seen at Table 3.1, the main differences between R&D business services teams and 24H teams are the duration of the Project, a presence of Prototyping, Manufacturing, Commercialization stages, and the high expertise in a design domain of R&D teams; these three last factors not were observed in this research.

Table 3.1 Comparison among teams of R&D teams and 24H teams

| | **Research Participants** | | |
|---|---|---|---|
| **Characteristics** | **R&D Teams** | **24H Teams** | **Similarity** |
| **Size** | 5 to 10 employees | 1 to 12 teammates | Yes |
| **Project participation** | By stage and by domain | By domain | No |
| **Organization** | By Project | By project | Yes |
| **Call for project** | Director | By leader | Yes |
| **Expertise** | High | Low | No |
| **Access to information** | High informal networking (Chapter 2) | Medium, some experts and Internet | No |
| **Motivation** | Work salary or business profit, growing business, recognition | Prizes, recognition | Yes |
| **Networking** | High developed | Low (to be built) | No |
| **Project duration** | 3 to 6 months | 1 day | No |
| **Stages of product development** | All (design and prototyping, manufacturing, commercialization) | Conceptualization (planning) | No |

## 3.6 Validation of the data collected

As illustrated in Figure 3.1, there are three methodological steps to collect the data about: 1) context surrounding teams for innovation, 2) needs, tasks and activities of creative teams, and 3) testing the performance of teams with a platform as support. The first step consists in obtaining data from collaborative interactions to achieve innovation. This qualitative data is obtained from different studies, described in Chapter 1 and 2. The data collection in the second step will be done using a complementary questionnaire covering the technological and methodological needs of creative teams. The needs and the analysis of the state-of-art of ICT technologies are presented in Chapters 4 and 6. For collecting the data in the third step, it is developed a prototype (modeling at Chapters 5 and 6) and a research instrument to assess the creative collaboration performance (which had been presented to the ÉTS Ethical Review Board; see Appendix I), which enables the data validation through prototype testing (Chapters 7 and 8). We shall describe first and third steps in more detail in the next four subsections.

### 3.6.1 Identification of knowledge, strategies and methods used in creative collaboration

A central point in our research lies in describing the knowledge production at the teamwork level. Creative teams can be influenced by conditions imposed by their context; however, they develop particular strategies allowing them to improve their performance. Interaction among members of creative teams is not only a consequence of geographical proximity; creative teams have to be involved in a conceptual/cognitive shared “collaborative espace”. Understanding this sense of integration is the main goal that generates creative collaboration. Consequently, we propose the analysis of three main points regarding team collaborative performance:

- Communications needs and resources used to identify interactions related to knowledge and ideas production and exchange
- Creative team performance (mainly considerations to achieve creative collaboration)
- Effective methods and strategies for distributed conditions (See Chapter 6)

### 3.6.2 Ideality (TRIZ) and ICT Collaborative Platform design

In this methodological step, we leap to a technological dimension that transforms the knowledge acquired about collaboration (first steps of research) into an ICT platform that enhances the ideas of its users for creative collaboration. A collaborative platform is a technological development that responds to the KMS (Section 1.3) which supports the socio-cognitive and technology tools that creative teams need to collaborate. A platform for collaboration could be considered as a Portal of Knowledge Management (Lee, Kim and Koh, 2009) or a Cloud that supports knowledge produced, meaning collaboration (Marlowe et al., 2011). As mentioned by Rollett (2003), the development of ICT tools could be seen as a knowledge management strategy, which could initially stimulate knowledge sharing or knowledge retrieval, and in a second step, could obtain a creative purpose:

> "The range of tools supporting content creation is not restricted to applications allowing people to explain their existing knowledge. It also includes tools meant to stimulate creativity. One popular method is random words, short text, and pictures from a suitable pre-selected collection at the right time" (Rollett, 2003, p. 138).

How can ICTs be used as a medium that enhances knowledge inspiration or conceptualization resources in developing a new product? Also, how can the different produced knowledge outcomes during the discussion and reflection process revolving around a new product development be included? The ICT collaborative platform must efficiently enhance the way in which knowledge is exchanged in addition to delineating a new interaction model.

In TRIZ method[5] (Semyon and Savransky, 2000), the technology evolution process obeys the S-shaped Curve directed from the pass systems to the ideality. As it occurs in all technologies, there is a constant tendency towards ***ideality***. "Ideality is defined as a ratio of the sum of

---

[5] TRIZ, from the Russian acronym ARIZ (Altgoritm Reshenia Izobretatelskih Zadach) is the Theory of Inventive Problems Solving proposed by Genrikh Altshuller in 1946. Altshuller studied more than 1000 patents to identify the ARIZ algorithm and 40 principles of contradiction used by inventors (Semyon et Savransky, 2000). TRIZ is a modular method, some of the most common parts are continually used for technical problems and mechanical design, however the use of their modular sections could be extended to all domains, as in our case, that it is applied to a ICT problem.

all useful functions and other benefits versus the sum of all harmful functions and undesirable factors ("costs and pains") associated with useful operations and benefits" (Zlotin, Zusman and Hallfell, 2011, p. 128). Based on this approach, we might establish the useful and harmful operations. We obtained this data by questioning users during a project development (Chapter 4). The questionnaire allowed us to gather needs, specifications and teamwork conditions in a creative project development context.

The ideality formula proposed by Cavallucci (2012) reads as follows:

$$I = \frac{\sum F \text{ useful operations and benefits}}{\sum F \text{ harmful} + \sum F \text{ cost, pains}} \quad (3.1)$$

*Ideality Formula*

According with the Ideality Law of technological systems, the technology evolves in S-shaped curve from the pass towards an ideal design (Kucharavy and De Guio, 2011) and it drives to foresee the technology in a systemic evolution. Figure 3.2 also allows the understanding of some undesirable effects that we have to considerate in the design of the platform: First, the rapid obsolescence of ICT systems makes them quickly unusable. Secondly, ICT disaggregates multiple functionalities in different software, operating systems, media and networks. Third, if we aggregate software or isolated functionalities, we cannot satisfy all user needs for ideation and creative exchanges.

### 3.6.3 UML 2 and specifications

The definition of a creative collaboration platform using ICT is represented by a language that integrates the results obtained in the previously proposed studies (social dynamic, method and strategy) and the digital space functions[6]. For this, we chose the UML 2 modeling language (***"Unified Modeling Language"***) or UML™.

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[6] Otherwise the existence of other methods, such as the Rational Unified Process (RUP), Extreme Programming (XP), Agile modeling methods or prototyping methods and Joint Applications Development (JAD) or Rapid

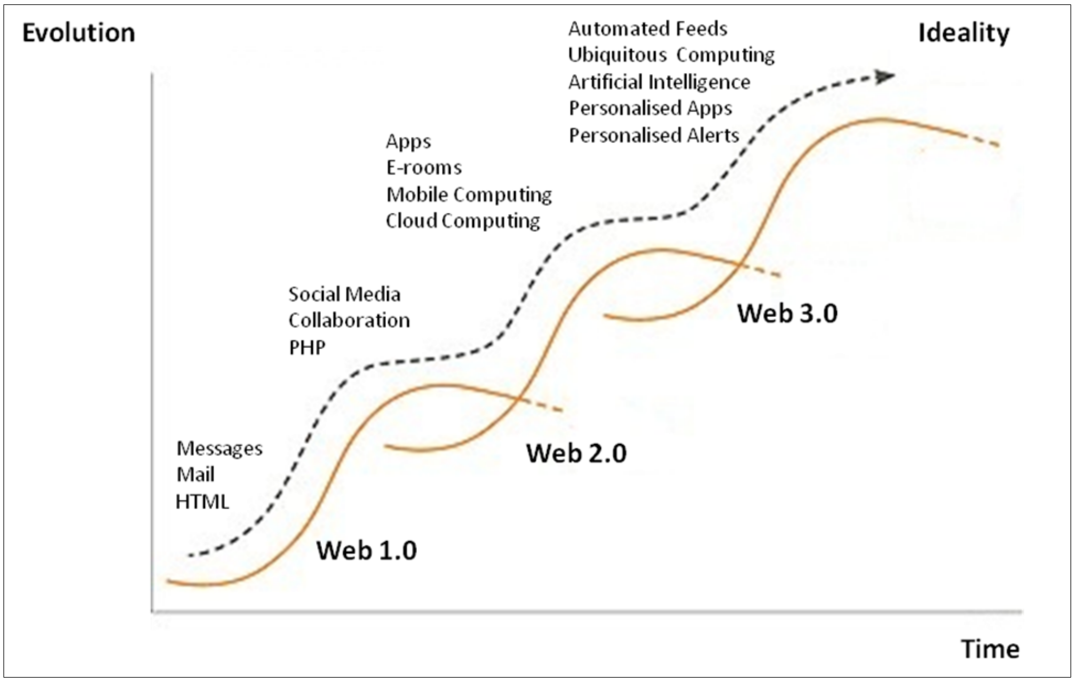


Figure 3.2 Proposed S-shaped curve evolution of Collaborative Technologies

This language is “a graphical notation designed to represent, specify, build, and document software systems. [UML has] ... two objectives: modeling of systems using object-oriented technology, from design till maintenance, and the creation of an abstract language understandable by humans and interpretable by machines” (Charroux, Osmani and Thierry-Mieg, 2008, p. v). In Figure 3.3, we show the procedure for representing the platform by UML 2. UML 2 has a fundamental advantage, which is the simplicity of use cases. The use cases enable the definition of the main functions that contribute to the delimitation of the KMS and reduce the cost and the induced errors from system fragmentation or multiple functions. In addition, the simplicity is important because it removes the need for processes and tasks that do not add value to the system.

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Application Development (RAD). We consider that the utilization of UML 2 enables the use and analysis of interactions and user activities, which are widely analyzed for us in the first part of our research.

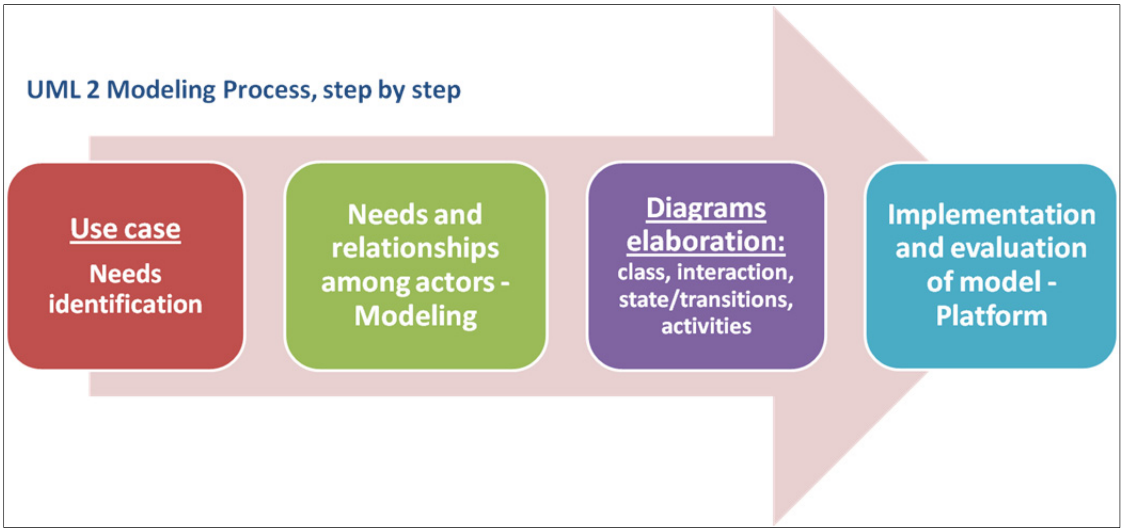



Figure 3.3 Step-by-step process to represent the collaborative platform
Adapted from Charroux, Osmani and Thierry-Mieg (2008)

The advantage of designing the system based on the ***use case model*** is that it enables the definition of the needs in the use of the system "effectively stated from the perspective of the user [...]. A complete and unambiguous use case describes one aspect of usage of the system *without presuming any specific design or implementation*" (Rosenberg and Scott, 1999, p. 39). The design process resulting from the use case modeling involves a description of the whole system functionality (ibid). This process differs from other ***modular design***-based models (thinking in fragmented pieces that will be assembled in the system), or the ***waterfall design,*** or ***incremental*** approach (from main or more complex functions to peripheral functions) (idem).

### 3.6.4 Prototype and users test

We assessed the individual and the collective satisfaction in the use of the platform based on responses of potential users (24H teams), after a period of use. The first designed KMS (mock-up or prototype) will be tested by performance and usability measures. Data is collected through forms (questionnaires) or structured or semi-structured interviews.

Generally, user experience tests are designed for the assessment of individual interfaces; this is our major methodological challenge in the evaluation of a collaborative ICT tool. Coutaz and Balbo (1994) show the difficulty in evaluating multi-user interfaces and propose observation as a method for analyzing groupware or platforms. Herskovic et al. (2007, p. 2) explain that the evaluation of groupware depends on its state of development and the general conditions of research, such as the location, costs or "stakeholders (developers, users and the organization) and the state of the product (under development or finished)" (idem). For groupware evaluation, they propose the following methods:

> "Groupware Heuristic Evaluation (GHE), Groupware Walkthrough (GWA), Collaboration Usability Analysis (CUA), Groupware Observation, User Testing (GOT), Human-Performance Models (HPM), Quick-and-Dirty Ethnography (QDE), Performance Analysis (PAN), Perceived Value (PVA), Scenario Based Evaluation (SBE), Cooperation Scenarios (COS), E-MAGINE (EMA), Knowledge Management Approach (KMA)" (idem).

To overcome the cited limits to the study of performance in a collaborative platform, we selected four evaluation methods: 1) "uses case acceptance" to validate the new functionalities proposed, 2) Task analysis, 3) Performance Analysis (PAN) and 4) Usability test – qualitative analysis. These methods are defined as follows:

#### 3.6.4.1 Use-cases acceptance by users

This test consists in verifying the use of a prototype of a Collaborative Platform to validate the use cases chosen to design the prototype (Chapter 7). Eriksson et al. (2004) indicated that the UML 2 is a modeling language that provides an incremental approach to improving the system. This improvement process is interactive based on testing use cases with two related goals: *"verification"* and *"validation"*. Verification confirms that the system is implemented correctly according to the requirements, specifications and the design; while validation ensures that the system under development actually addresses the customer's needs. Use cases "help validation by providing a method to test the system for observable benefits to actors" (Eriksson et al., 2004, p. 77).

- The data collection in this study is obtained by the descriptive statistics of the direct use on the prototype.

#### 3.6.4.2 Task Analysis of Knowledge Management System

As we mentioned in Section 1.3, a Knowledge Management System is a set of tools and knowledge used to complete a task. Task analysis is a process to define the specific steps involved in achieving a task. This description is detailed and includes cognitive and psychomotor actions performed by a person to carry out the task. Some of the details include: sequence of steps, duration, frequency, task allocation, complexity, environmental conditions, necessary prerequisites (e.g. tools). (Crandall, Klein and Hoffman, 2006). This study is focused in "what user is required to do in terms of actions and/or cognitive process to achieve the task" (Dalkir, 2012, p. 475). Crandall, Klein and Hoffman (2006) affirm that this process is particularly useful to analyse ICT because "these technologies and deliver on their promises only if they are designed and engineered to support cognitive functions" (p. 173). This method allows the recognition of how the ICT platform is used during the product development.

- The data collection in this study is obtained by a form of closed questions every three hours

#### 3.6.4.3 Performance Analysis: creative activities

The third test is the Performance Analysis (PAN) proposed by Baeza-Yates and Pino (2006). In this method, "the application to be studied is modeled as a task to be performed by a number of people in a number of stages, and the concepts of result quality, time, and total amount of work done are defined. The evaluators must define a way to compute the quality (e.g., group recall in a collaborative retrieval task), and maximize the quality vs. work done, either analytically or experimentally". This method implies the observation of the amount of work realized by the team during different stages of the project and the changes in tasks (Antunes et al., 2008), presented in Chapter 8, after the 24H team tested the platform. The task of creative collaboration was assessed for the effective use of functionalities of the platform. These data obtained will allow us to improve the collaborative performance in the early ideation stages.

- For the performance analysis, it is necessarily develop an assessment test, which is applied after the use of the prototype.

Measuring performance inside an environment or using a new product implies a contrast among a previous use and the use in a new situation. In our study, we are not able to measure the improvement of the creative collaboration meaning the platform, because it is a beta product. This kind of research about performance should require a longitudinal study. However, we consider that applying a performance test is useful to define the users' perception about how the platform facilitates the idea production and the process of collaboration.

#### 3.6.4.4 Usability: qualitative analysis

Usability is defined by Bevan (2009) as:

> "a set of attributes that bear on the effort needed for use, and on the individual assessment of such use, by a stated or implied set of users. This definition of user interface usability contrasts with the system perspective of usability defined from an ergonomic point of view in ISO 9241-11 (1998): Usability: The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (p.14).

Bevan (2009) identifies seven criteria for measuring usability: Effectiveness, Efficiency, Satisfaction, Likability, Pleasure, Safety, and Comfort. In this research, the satisfaction is measured by a qualitative analysis of the "problems" and low rated score of performance mentioned by users during their experience using the prototype of the platform.

- The usability is measured by the means of an open-questions form, detecting the problems or non-satisfaction comments expressed by users.

## 3.7 Limits of the study

Several limits to this study should be noted. A first limitation is due to the complex nature of creativity assessment. In this study, we could not affirm that an artifact as the platform could improve individual or team creativity, because the creative performance depends on psychological and social conditions. However, we uphold the fact that the creativity could be effectively supported by increasing the probabilities of contact with external experts, collaboration among team members, and convenient use of media. For this reason, this study is focused on the support of the creative collaboration.

A second limitation is the timing and cost difficulties to analyze when a creative team achieves an innovation, because it implies a long-term research. In the field of innovation research, the researcher has to take a big sample of all teams that worked in a new development and wait over 2 years to observe if one of the designed products was accepted by the market. In our study, this justifies the choice of the analysis of the Canadian statistics. This study took a sample of R&D enterprises that effectively reported an innovation. In addition to this second limitation, it could be better to follow-up the winner's teams of 24H. However, following only the winning teams is extremely difficult because not all of them agreed to participate and the sample would be extremely small.

A third limitation for assessing the performance of teams using the platform is the absence of a control group. This limitation is common among the beta version of a software or prototype being tested. However, as Roger (2013) mentions, a first testing enables the designer to observe the "possible ways of improving the product" (p. 209). Further research inquiry is needed to compare the performance of creative teams into the platform in contrast with others groupware or tools.

## 3.8 Summary

In this chapter, we have presented our problem statement related to the distribution of tacit and informal knowledge and the distribution of creative team members. Also, we have presented all the implications of ICT tools in the sharing of informal knowledge. Methodologically, we respond to the problem statement defining four objectives. For the design of the collaborative platform, we employ the evolutionary trend based on the TRIZ "ideality law". ICT functionalities will be presented using UML 2, and the collaborative user experience test is realized using the Performance Analysis Method (PAN).

In the next chapters, we present three studies realized to answer the research question: *How is it possible to support the distributed creative collaboration through a knowledge management system and a collaborative ICT platform for ideas and knowledge sharing?*

In this thesis we presented three steps of the research development, the first, presented in Chapter 4, describes the study of the needs and ideals exposed by creative teams that allow us to complete the study on the use of collaborative functionalities. Secondly, Chapters 5 and Chapter 6 describe the technological dimension of the platform design (modeling the Knowledge Management System) and the development of a prototype of a collaborative platform for testing the main functionalities, and thirdly, in Chapter 7 and Chapter 8, we presented the test of user experience during a first beta test of a prototype. Our study focuses only on the analysis of creative R&D activities, and on the interaction that drives teams to design innovative products.

# CHAPTER 4

# UNDERSTANDING NEEDS OF CREATIVE TEAMS

This chapter summarizes the needs of knowledge acquisition (task, tools and sources of knowledge) expressed by the almost 142 out of 250 participants (who agreed to participate in this research) attending the Fourth edition of 24H de l'Innovation (*24 Hours of Innovation*) (November 2011), with the responses about the ideal conditions for sharing ideas and knowledge within and outside the team. This chapter is based on work by Jiménez-Narvaez, Dalkir and Gardoni (2012). These data provide the methodological issues to define the Knowledge Management System (KMS) (information needed to design a collaborative platform) that enables interactive collaboration among participants in a new product development.

## 4.1 Knowledge acquisition process in a new product definition

One of the most useful approaches of knowledge acquisition analysis is purported by Dalkir (2012) consists of analyzing three knowledge acquisition phases: "identification, conceptualization and codification" (p. 117). Table 4.1 provides an explanation of each knowledge acquisition phase. The first phase, ***identification,*** refers to the process of characterizing key problem aspects such as participants, resources, goals, and existing reference materials (idem). In a design team, this phase allows teammates to analyze the project context and to also recognize constraints and limitations identified by participants such as industrial stakeholders, market or consumer expectations and team members. The second phase, the ***conceptualization*** of the project or the product is realized comparing concepts among teammates. In this phase, the production of content is necessary to exchange information. In the last phase, the ***codification***, teams represented their project solution by detailed images produced with CAD software, photos of a mock-up or videos.

Table 4.1 Phases of knowledge acquisition and research statements

| **Phases of knowledge acquisition** | **Process of knowledge acquisition** |
|---|---|
| Identification | What knowledge was needed to "capture" the context during the project? |
| Conceptualization | How were the key design concepts defined by the team? |
| Codification | How was the new design represented by the team? (to be understand the new product information inside and outside the team) |

## 4.2 Defining the use of ICT to acquiring knowledge

Despite the existence of an array of ICT services or knowledge toolboxes such as groupware options, extranet and intranet networks and databases that allow the knowledge exchange among design teammates, the satisfactory conditions to collaborate are not yet established. The fact of adding communication tools did not alleviate the problem of effective exchange and communication in creative teams. According with Gruber and Duxbury cited by Dalkir (2012, p. 234) some possible causes are related to the difficulty of foreseeing new situations especially because the forecast information "is hard to find, there were different systems and no standards, the information was not where it should be, the tools were difficult to use and the database was difficult to access" is not enough to have modeling tools to support knowledge sharing, because satisfactory team performance also depends on team dynamics: "training of knowledge retrieval, to define a knowledge strategy that would categorize in a standard way, to standardize the information technologies, and to create project web sites" (idem). In the analysis of product forecasting, design teams used knowledge that is provided by different sources. There are approaches based in social demands as client requirements (Forgues, 2006), consumers participation (Helander and Jiao, 2002) or the product modeling with CAD technologies (Demoly et al., 2010; Quintana et al., 2010). We observed that these approaches are complemented in a whole framework.

As the result of this reflection, we became interested in understanding and harnessing the complexity of managing knowledge needs of design teams: *What is the knowledge acquired by a team when forecasting new product/ process? What types of tools are needed to create and share this knowledge?* We explore this knowledge acquisition process and tools by the way of task analysis method that was presented in the Section 3.5 on the Methodology.

### 4.3 Description of the study: Participants and Procedure

Almost 250 students attended the fourth edition of the 24H competition and 142 agreed to participate in the research study (November, 2011). During the competition, we sent out online forms to all registered students who had agreed to participate in the research. This was an introductory questionnaire about some biographical information and teamwork experience, open-ended questions every two hours about which design process stage they were at, and what knowledge and tools they had needed and used. There were a total of ten forms; participants had to submit if they worked in that two-hour period. They then completed and submitted a final user satisfaction questionnaire at the end of the competition. The questions about the phases of knowledge acquisition were asked at 6H, 14H and 22H, respectively.
We studied three variables linked to this process:
1) Visualization of the representation of ideas during the three stages of acquisition knowledge: identification, conceptualization and codification, proposed by Dalkir (2012);
2) Information sources (cognitive and knowledge exchanged) used effectively by the teams for idea exchange demand (project proposals) or teamwork among team members and external experts, partners or sponsors;
3) Communication tools used during knowledge sharing stage.

Figure 4.1 shows some characteristics of participants. On average, 50% completed and submitted the questionnaires, and of these, 57% were undergraduate students and 37% were Master’s students. Approximately 73% said they frequently used from 1 to 5 groupware systems and 19% used more than 5 groupware systems. Most respondents were project development team members (69%) and 44% reported that they had team leadership experience.

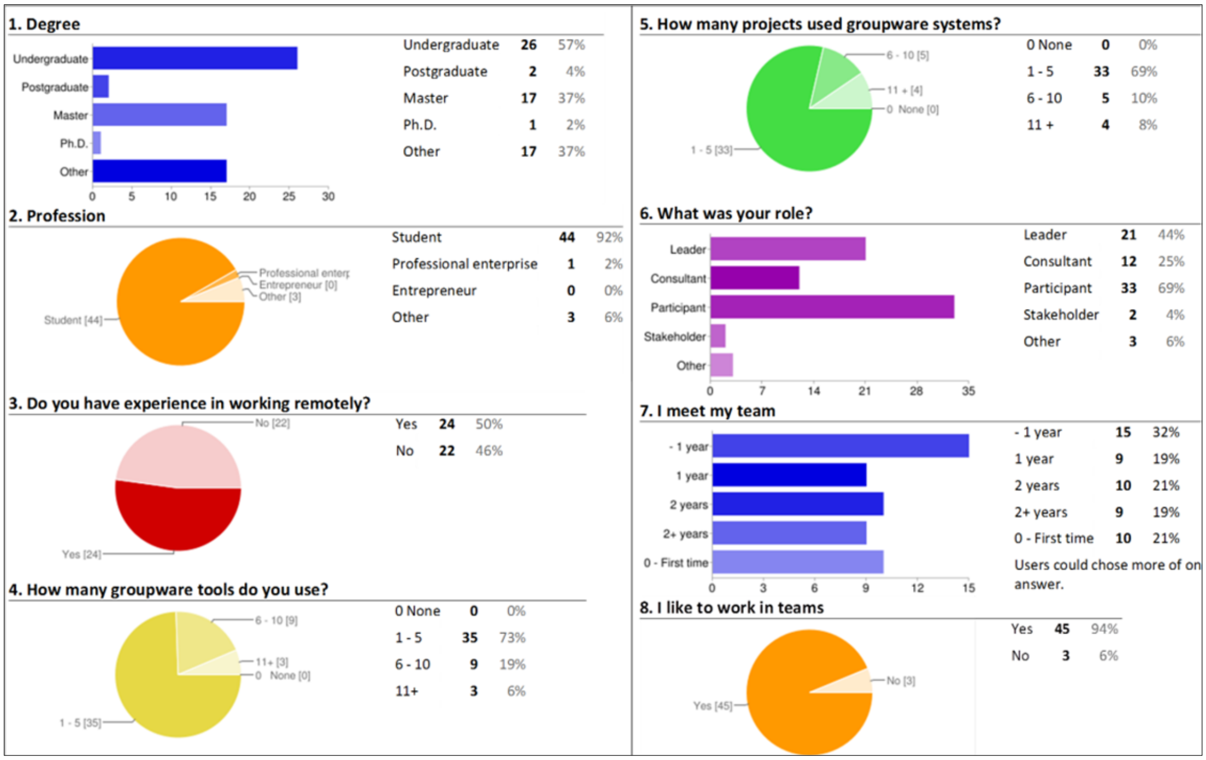



Figure 4.1 24H participants' biographical information

Students who had previously worked together tended to be on the same 24H team. 32% had not worked together for more than a year, and only 19% responded that they had worked together for two years. 94% of participants reported that they were comfortable working in teams. Table 4.2 presents the teams composition, including the number of members, the host universities or institutions and countries of origin.

## 4.4 Results

### 4.4.1 Knowledge acquired from internal and external sources

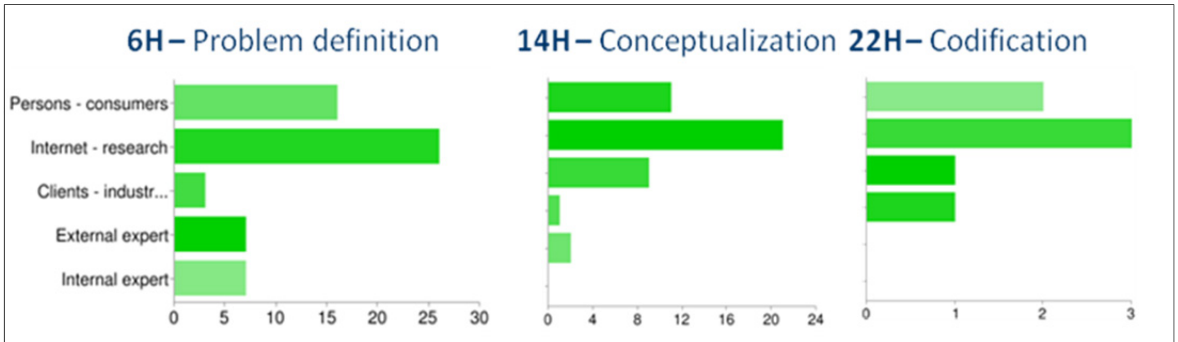
In Table 4.3, we observe how teams and partners acquire knowledge in three stages: problem definition, product conceptualization, and codification. Table 4.3 shows how participants acquire knowledge to define a product from external sources of information, in the first stage of problem definition: 44% of participants used the Internet and search engines as a main information source, 27% of participants requested people or consumer information sources, 12% of participants requested to external and internal experts, and 5% of participants contacted industrial representatives.

Table 4.2 Teams composition by participants and schools

| Country | N. | Team | Participants | Institution | Domain |
|---|---|---|---|---|---|
| **Belgium** | T1 | Les Zips | 5 | ESA - Saint Luc | Industrial Design, Mechanical Eng. |
| | T2 | HEC-Ulg | 6 | HEC-Ulg | Bussiness |
| | T3 | ICW | 5 | HEC-Ulg | |
| | T4 | Limitless conception | 7 | HEC-Ulg | Economics, MBA |
| | T5 | SAFEA's Troglodytes | 8 | HEC-Ulg | Economics, Bussiness Administration |
| | T6 | La fourmilière | 4 | HEC-Ulg | Finance |
| | T7 | ID-Brakers | 5 | HEC-Ulg | Economics |
| | T8 | Groupe1 | 5 | HEC-Ulg | Finance |
| **Canada** | T9 | Les zombilistes | 3 | ETS | Industrial and Electrical Engineering |
| | T10 | D-2913 | 6 | ETS | Automatized Production Engineering |
| | T11 | 15HP | 7 | ETS | Informatics IT, Mechanical Engineering |
| | T12 | INGénieuses | 6 | ETS,UTC TUBS | Mechanical Eng, Communications and Networks, Human Factors, Industrial Design, Aerospace |
| | T13 | Innov'UTC | 9 | ETS, UTC | Automatized Production Engineering |
| | T14 | Moonlight | 3 | ETS, UTC | Automatized Production Engineering |
| | T15 | MidgETS | 7 | ETS, UTC | Logistics and Operation Engineering |
| **France** | T16 | Kandasamy | 3 | UNIV-MLV | Mechanical Engineering |
| | T17 | ESIPE -MLV | 3 | UNIV-MLV | Mechanical Engineering |
| | T18 | ESIPE 1 | 3 | UNIV-MLV | Mechanical Engineering |
| | T19 | Purple | 1 | UNIV-MLV | Mechanical Engineering |
| | T20 | ESTIA-Zip | 3 | ESTIA | Mechanical Engineering |
| | T21 | Duck'y duck | 2 | UTBM | Design and mechanical Engineering |
| | T22 | Les 6 fantastiques | 6 | UTBM | Design and mechanical Engineering |
| | T23 | mécaZip | 4 | UTBM | Design and mechanical Engineering |
| | T24 | Les tuques | 3 | UTBM | Design and mechanical Engineering |
| | T25 | Les Woodchucks | 6 | UTBM | Design and mechanical Engineering |
| | T26 | Innov in the soul | 4 | UTBM | Design and mechanical Engineering |
| | T27 | The team of the time | 5 | UTBM | Design and mechanical Engineering |
| | T28 | Duck'y duck | 4 | ISA | Agro-research |
| | T29 | Duck'y deck | 7 | ISEN | High Technology and Innovation Design, Agro-research |
| | T30 | Flo et les garcons | 2 | ISEN | High Technology and Innovation Design, Agro-research |
| | T31 | Barnique-veritas | 6 | ISEN | High Technology and Innovation Design, Electonics and Informatics, R&D |
| | T32 | Bazinga | 4 | ETS, Poly, UTBM | Design and mechanical Engineering |
| | T33 | Seven-Team | 4 | ISEN | High Technology and Innovation Design, Electonics and Informatics |
| **Reunion Island** | T34 | Team 1 | 5 | Lycée Lislet Geoffroy | Electricotechnical |
| | T35 | Team 2 | 5 | Lycée Lislet Geoffroy | Electricotechnical |
| | T36 | Team 3 | 5 | Lycée Lislet Geoffroy | Electricotechnical |
| | T37 | Team 4 | 5 | Lycée Lislet Geoffroy | Electricotechnical |
| | T38 | Team 5 | 5 | Lycée Lislet Geoffroy | Electricotechnical |
| | T39 | Choc | 5 | Lycée Lislet Geoffroy | Electricotechnical |
| **Senegal** | T40 | Teamudz1 | 1 | Université de Ziguinchor | Informatics |
| **Total** | **40 Team** | | **187 Participants** | | |

ESTIA-École Supérieure des Technologies Industrielles Avancées
ETS- École de technologie supérieure,
ISA - École de l'agriculture, l'agroalimentaire, l'environnement et du paysage à Lille
ISEN- École d'ingénieur généraliste en haute technologie ingénieurs
Poly-École polytechnique Montreal
UNIV-MLV Université Paris-Est Marne-la-Vallée - Ecole d'ingénieurs par apprentissage des sciences et technologies
UTBM-Université de Technologie de Belfort-Montbéliard-
UTC-Université technologique du Compiègne

Table 4.3 Knowledge provided by external sources by period of time




| | 6H - n | % | 14H - n | % | 22H - n | % |
|---|---|---|---|---|---|---|
| **People - consumers** | 16 | 27 | 11 | 25 | 2 | 29 |
| **Internet - research** | 26 | 44 | 21 | 48 | 3 | 43 |
| **Clients - industrial constraints** | 3 | 5 | 9 | 20 | 1 | 14 |
| **External expert** | 7 | 12 | 1 | 2 | 1 | 14 |
| **Internal expert** | 7 | 12 | 2 | 5 | 0 | 0 |
| **Other** | 0 | 0 | 0 | 0 | 0 | 0 |

The external expert also has a role at the end, during the codification stage (14%). Industrial constraints are consulted 20% of the time during the conceptualization stage. We observe a need of exchange with clients/industrial constraints in the first two stages. For the external expert, his/her presence is needed in the first stage of problem definition.

### 4.4.2 Knowledge and information exchange among team members

Within the teamwork dynamic, we observe that each member is a source of knowledge (information and ideas) and decisions for the team; this activity is directly influenced by social interaction, as observed in the number of exchanges and the dynamic among team members. In Figure 4.2, we observe that at the start of the 24H competition, entire teams work together during specific moments, for 8 hours, as well as at the end of the 20-22 hour period. This data is useful for understanding the teamwork dynamic, because teams do not always work simultaneously, and because the dynamic is supported by the work that takes place between subgroups of 1 to 3 members. Further, information obtained from sponsors, clients and the organization boards was not continuous during the innovation process, but it has to be provided as soon is needed to maintain the flow of the teamwork dynamic. This specific need of external exchanges could be a justification of the use of ICT technologies (Gottschalk, 2005; Rao, 2005).

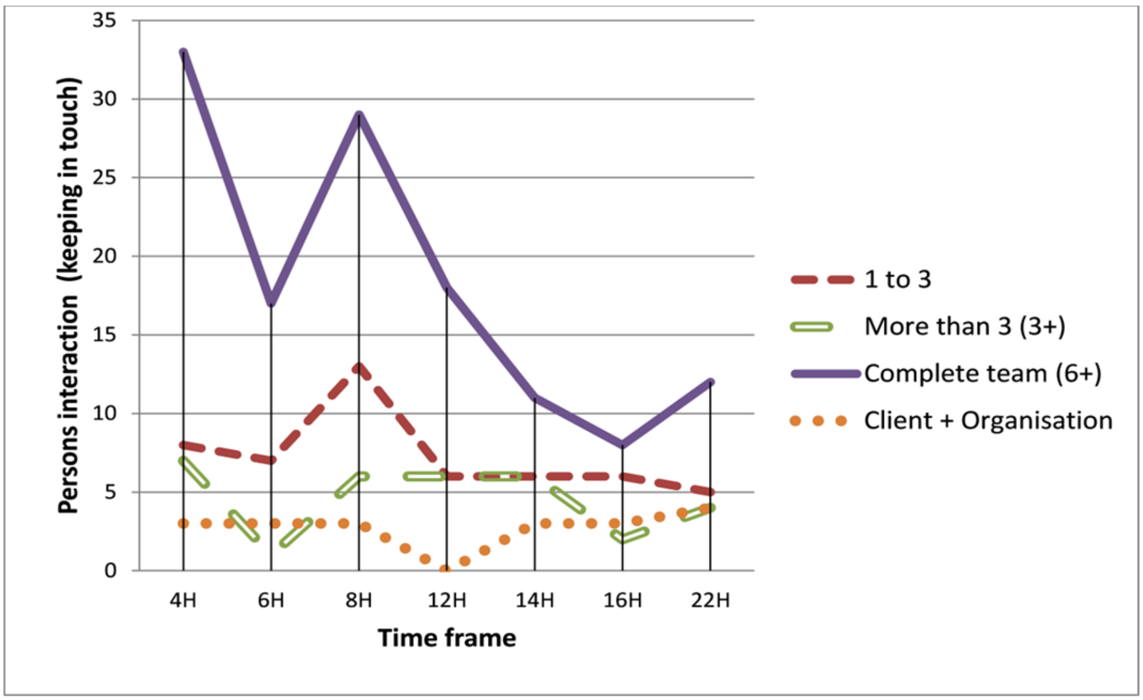



Figure 4.2 Exchange of information among teammates, client and organization in a social teamwork dynamic (number of meetings and number of participants)

### 4.4.3 Production of ideas by participants during internal teamwork

In the early stages of the design process, teams developed different ideas in different quantities at the individual level; these ideas contributed to the completion of the project definition. Nijstad and Stroebe (2006) affirmed that the creative teamwork dynamic is composed of two kinds of interaction loops among teammates: the image retrieval loop and the idea production loop (Nijstad and Stroebe, 2006, p. 193). This iterative process between knowledge acquisition (first loop – image retrieval) and knowledge exchange (second loop – idea production) allowed participants to share information, knowledge and insights about project development. We must recall that 24H teams are in an international competition, which results in highly competitive behavior and encourages creative discovery within a short time period. In Figure 4.3, we can observe active creative production, as evidenced by the number of ideas produced, and reported by each participant.

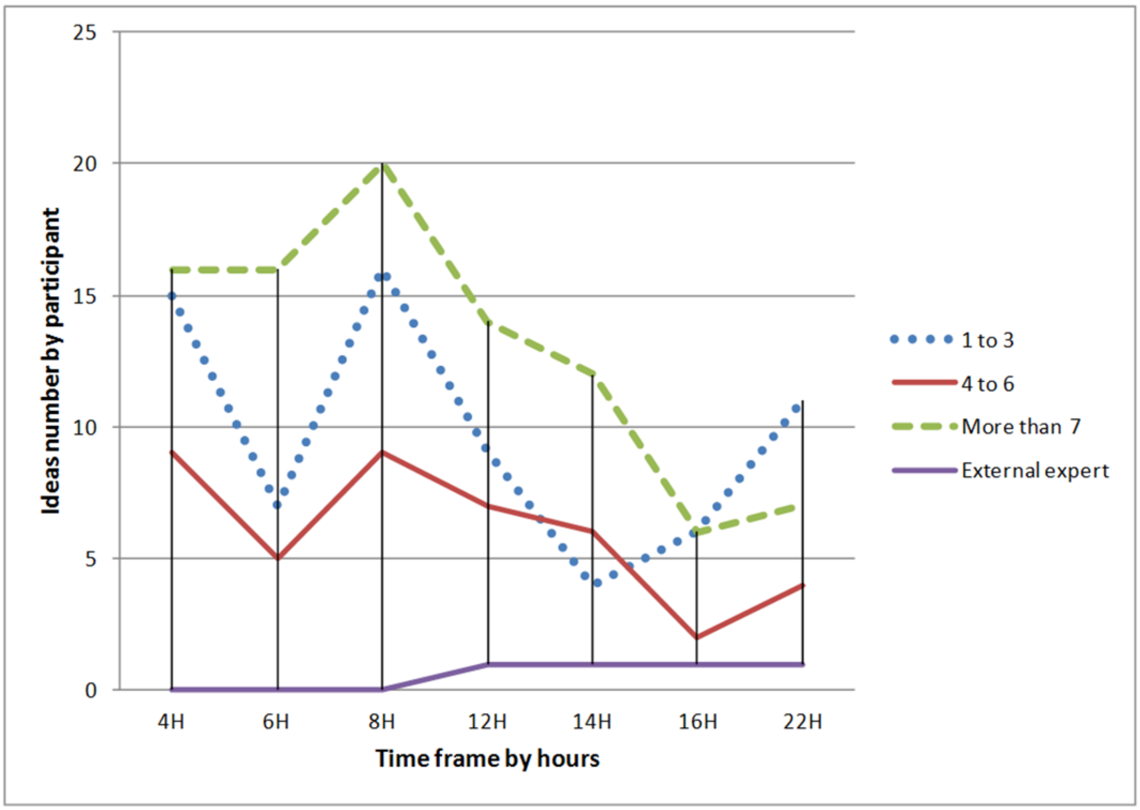



Figure 4.3 Number of individual ideas produced over time.

We also observe that participants produced large numbers of ideas during each part of the project. External experts had low participation in teamwork. And also, there is a low production of ideas during the last part of product definition. Nijstad and Stroebe (2006) also proposed that this inter-loop dynamic increases the diversity of ideas production in the wide range of semantic categories making up the design stage. This fluidity is reflected in the number of ideas produced during the entire project. Participants indicated a fluid activity (more than 7 ideas per two-hour period) of idea production (Nijstad and Stroebe, 2006, p. 204), especially during the first 8 hours of the problem definition.

## 4.5 Identification of ICT Tools used in product definition

We found that there was a wide variety of ICTs used to support the R&D team, and that they supported four activities: information acquisition, knowledge representation, changes management and knowledge sharing. However, in accordance with participants' answers implementing ICT tools was not sufficient to support knowledge sharing. Figure 4.4 shows the wide range of tools observed in use for sharing knowledge and a generally broad range of variations in the use of ICT technologies during the 24H competition. Participants used the Internet as the main tool for searching and acquiring knowledge.

In other words, the Internet was a source of information for innovation activities, in addition to being a knowledge sharing tool. Participants used the search engine and information from patent databases as references to determine the "state-of-the-art" of the technology of the product that they were currently developing. Responding to an open question about critical tools used in product development, respondents agreed that the Internet was a critical tool for arriving at an innovative solution, as shown in Table 4.4. We present a detailed explanation in the next section.

In the close question about the critical tools (see Figure 4.5) teams responded that they required tools, particularly the "critical" tools to realize the project definition" (see Table 4.4). To assess these critical tools, we used the definition of "critical", in the sense of must-have tool or the needed tool as expressed by Collins (2007), cited by Rao (2005a), who defines five levels of critical need "critical, must have, important, nice to have and non-critical" to sustain team performance.

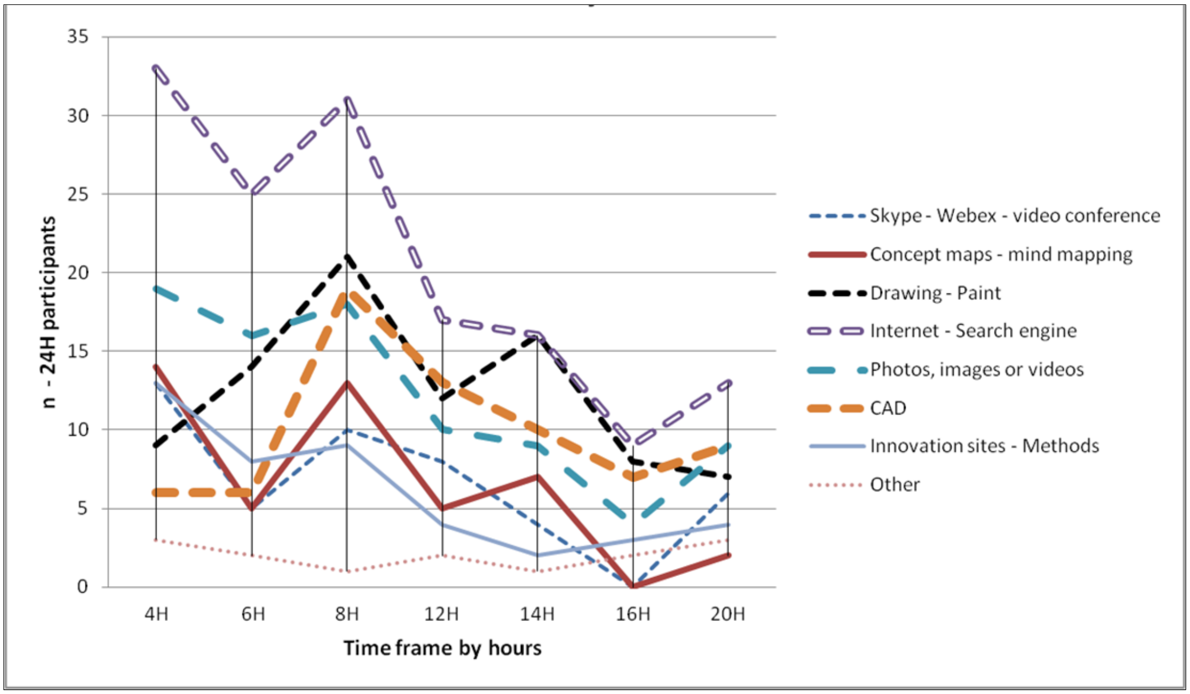
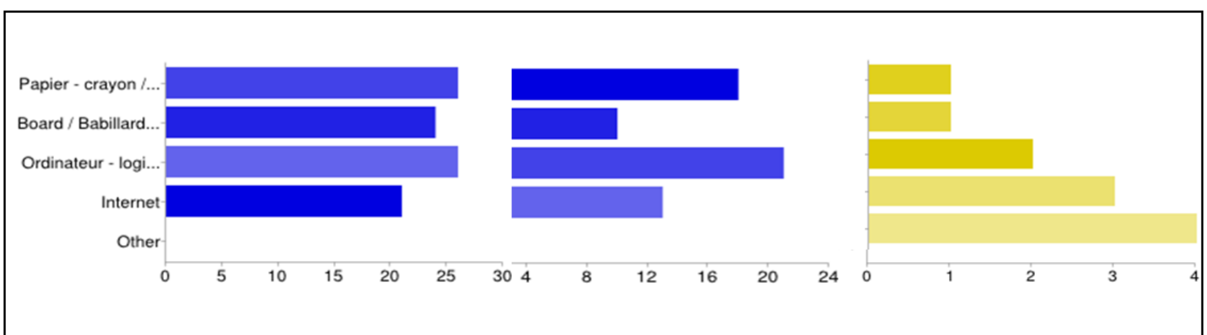



Figure 4.4 Tools and ICT technologies used by the 40 teams during a 24-hour period

As see in Figure 4.5, the use of paper and boards is also essential in the teamwork dynamic; this aspect entails a challenge in combining ICT with hand tools.




| | 6H -n | % | 14H - n | % | 22H - n | % |
|---|---|---|---|---|---|---|
| **Paper-pencil** | **26** | 93% | **18** | 75% | **1** | 20% |
| **Board** | **24** | 86% | **10** | 42% | **1** | 20% |
| **Computer** | **26** | 93% | **21** | 88% | **2** | 40% |
| **Internet** | **21** | 75% | **13** | 54% | **3** | 60% |
| **Other (Video)** | **0** | 0% | **0** | 0% | **4** | 80% |

Figure 4.5 Critical tools to exchange knowledge

Table 4.4 Critical tools to be used during a new product development

| Project Stage | Tasks | ICT –based Tool | Non ICT-based Tool |
|---|---|---|---|
| Problem definition | Inspiration<br>Watch technology<br>Art state | Internet Engine<br>Patents Database<br>Youtube | Simulations and body language |
| | Sharing links and files (Sharing content) | Google docs<br>Google groups<br>Dropbox | |
| | Problem Definition<br>Brainstorming – collective idea production | Brain, Freemind (Mind mapping tools) | |
| | Discussion<br>Communication tools | e-mail<br>Skype (audioconferencing)<br>Webex (videoconferencing) | Paper-Pencil<br>Board – markets<br>Post-its<br>Verbal notations |
| Conceptualization | Definition | Internet Engine<br>Google docs<br>MS-Word | Drawings<br>Images in a screen<br>Paper-Pencil<br>Excel |
| | Idea definition | Catia, Rhinoceros<br>MS-Power Point<br>Blackboard | Drawings, plans, models |
| | Discussion<br>Communication tools | e-mail<br>Skype (audioconferencing)<br>Webex (videoconferencing) | Paper-Pencil<br>Board – markets<br>Post-it<br>Verbal notations |
| Codification | Project definition | Catia, Rhinoceros, Solidworks<br>MS-Power Point<br>MS Movie-maker | Drawings, plans, models |
| | Storage or Web Content Management Tools | Google Docs<br>Dropbox | Remote file exchange |
| | Communication Tools | Dropbox<br>Skype (audioconferencing)<br>Webex (videoconferencing) | Co-presence or remote: verbal notations |

### 4.5.1 Cloud–computing and Internet as a critical source of knowledge acquisition for innovation

The Internet was the main tool used for a kind of trimmed "technology watch" and to obtain critical information about creative or innovative methods, as explained by participants. Technology watch is a "systematic procedure of capturing, analyzing and exploiting useful information for strategic decision making in a company or organization" (Legardeur, Boujut and Tiger, 2010). The goal is to conduct a complex technological research "based on the search and analysis of all technological information (especially patents) with the aim of catching development opportunities and detecting competitive threats while providing strategic choices for business decision makers". Patents Luxembourg Office - (Online – accessed April 2011). The Internet and ICT technologies were important vehicles of knowledge acquisition and knowledge sharing because they mediated the interaction (groupware); contributed to knowledge externalization (coauthoring or document production) sharing and retrieving of documents and easy visualization (Portals); to knowledge internalization by connecting training and resources between novices and experts (Learning Modeling Systems LMS); and finally, ICT technology supported workflows, decisions and visualization of knowledge, as mentioned by Koulopoulos and Frappaolo (2000).

As shown in Figure 4.4, 24H teams also used other platforms, such as Skype, a Web conferencing service that includes a chat or SMS function, allowing the rapid sharing of links and files. Cloud computing services (Zika-Viktorsson and Ingelgård, 2006) and search engines, were used during the entire competition, with the use being most intensive during the first 8 hours. In answering the open-ended questions about the use of these technologies, respondents expressed their wish for synchronous tools to be aware of project progress and to be able to share digital information. Co-located participants showed other members their computer screens whenever they found interesting information or data. When team members were not at the same location, they sent an e-mail or instant message with the information obtained. However, this kind of information sharing had its limits as the information contained may be difficult to read and priority information could be lost. For that reason, teams preferred to coauthor documents in two ways: using Google Docs and sharing and working on a common document using DropBox.

Despite the flexibility of the coauthoring option of Dropbox, there were some difficulties encountered in making changes to the project. Google Docs was found to offer more advantages, with its special coauthoring features, such as a modification panel per user, change history trace and the ability to add comments. The Google Docs coauthoring feature offered another advantage for large teams: all team members could participate simultaneously and observe or work on a different part of the same document. This contrasted sharply with the difficulty in using the MS Office Change History feature, as it became quite confusing when more than 3 people were participating, and after 2 revision cycles.

## 4.6 Discussion

As observed in this Chapter, the knowledge acquired by creative teams, during the early design phase: problem definition and conceptualization, was distributed by three conditions of interaction: 1) a large number of information exchanges among participants during the initial problem definition stage; 2) a social dynamic among team members and external experts, and 3) a large quantity of media/tools used to acquire knowledge, defining a problem, conceptualizing and codifying an idea.

This distribution of knowledge is a natural condition in a new product design dynamic and this distribution is not enough mitigate by the use of ICTs or the introduction of specific software of design, such as Adobe® Creative Suite® 5.5 or CAD software. We observed that the CAD tools are used in the latest stage of codification (Figure 4.4). All these ICT tools do not meet all the knowledge capture needs in the first stages of problem definition or conceptualization; as well, the simultaneous use of these tools cannot relieve or facilitate knowledge/ideas capture or sharing. In addition, 24H teams frequently use non-technological tools such as paper-pen, board-markers, and post-its to draw or write their ideas (as shown in Figure 4.5). All these media require a co-presence/face-to-face model that is not easy to maintain in an inter-institutional project.

In Table 4.4, we propose a classification of ICT technologies, especially of groupware systems in: 1) Communication tools, 2) Web-search Engines (Google), and 3) Content Production (for sharing changes and co-authoring outcomes). Project Management tools for planning or task assignation were not mentioned for the early design process. These tools must be part of a collaborative platform. According with the answers of 24h teams, ICT tools are used indistinctly by co-localized and in a delocalized teams, particularly to capture tacit knowledge from Internet (as a data-base) and from industrial partners or stakeholders.

### 4.7 Summary

In this Chapter, we model the needs of creative teams during three specific tasks: problem identification, conceptualization and codification of knowledge. Also, we identify ICT tools that support a collaborative ideation (ideas production) stage. The analysis of these conditions can lead to more effective knowledge acquisition and sharing during a collaborative project development. We conclude that the interactive process of co-ideation requires ICT tools that allow designers to manage knowledge acquisition processes involving actors, communication platforms, and the Internet.

Social interaction varied during different time periods – when the team worked together at the beginning of the event (conceptualization) and at the end (codification). During other time periods, the team worked in subgroups of one to three participants. This social interaction determined the use of ICT technologies. New applications such as Google Docs or Dropbox (cloud computing technologies) were used to co-author documents and to support the knowledge acquisition process.

In this study, we also discover during the early design phase, the collaboration is also distributed in three conditions due to peer-to-peer interaction: 1) a large number of ideas are exchanged among participants during the initial problem definition stage; 2) a social dynamic among peers, team and external experts, and 3) a large quantity of media/tools used to acquire, produce, represent and share the experiential design learning knowledge.

In the next chapter, we will define the main functionalities that an ICT platform must have in order to support the needs of creative teams.

# CHAPTER 5

# MODELING THE COLLABORATIVE PLATFORM AND SPECIFICATIONS

This chapter provides a detailed explanation of the conceptual model and the specifications needed to support creative collaboration among design teams. The design of the platform is presented by Domain Model, Ideality Formula and UML 2 (a detailed UML glossary is in Appendix IV). UML 2 describes the information, actors, use cases, and is also extensively used for "documenting software systems [...] UML has evolved dialects beyond the reach of official standards for such needs as data modeling, business modeling, and real-time development" (Eriksson et al., 2004, p. 1).

## 5.1 Supporting creative collaboration: domain model

For modeling the collaborative platform as a Knowledge Management System, it is necessary integrating: the knowledge objects (Chapter 1), the networking with expert sources for innovation obtained from Innovation and Businesses Survey (Statistics Canada, 2005; 2008; 2010) (Chapter 2) and the needs for capturing knowledge of 24H creative teams (Chapter 4). In a first level of interaction of the collaboration platform, the knowledge exchanged is divided into *known* and *unknown* components proposed by Frappaolo and Koulopoulos (2000) in its matrix of the Known-Unknown, in which the design team depends of internal and external sources acquire and exchanging ideas and knowledge, as presented in Figure 5.1.

Unknown knowledge is assumed to be new ideas generated by insights, feelings and emotions, while known knowledge is more closely related to memory and shared expertise. In fact, idea production is a process related to recalling memory and loops of association on thought (Nijstad and Stroebe, 2006), while knowledge production is related to our intellectual ability to process knowledge (Wenke and Frensch, 2003). In a creative team, each teammate contributes ideas and knowledge; these are two basic processes, so the success strategy for a creative team consists in precisely synchronizing (tuning in), integrating or selecting these contributions.

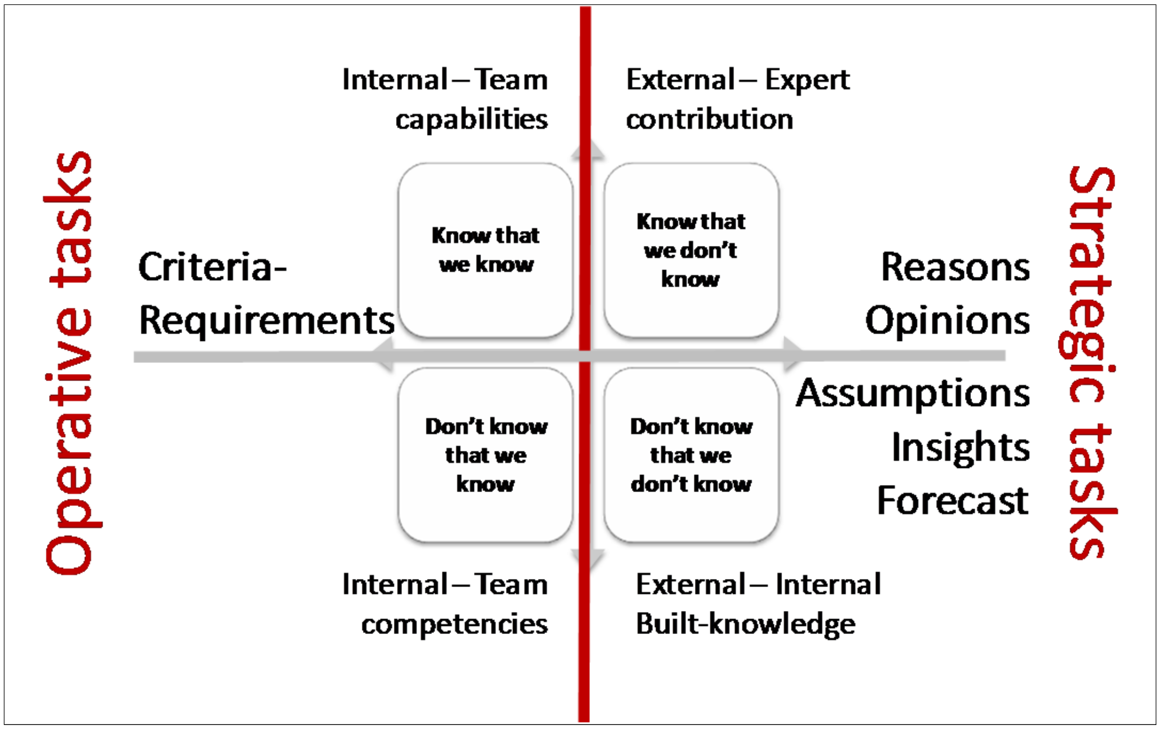



Figure 5.1 Knowledge sharing by an R&D team
Adapted from QOC Model (MacLean et al., 1991), Information System by Kunz and Rittel (1970), and Known-Unknown matrix by Frappaolo (2006)

Theoretically, operative tasks, as identifying in Chapter 2, are more easy of be exchanged through ICT, because they are codified; however strategic tasks among teams and stakeholders are less easy to be supported by ICT because they require meetings and discussions with external experts to the team or with the community (future consumers).

The above conceptualization is represented by the *Domain Model.* This "early domain model is useful to establish a core set of classes that represents the things in the problem space of the system to be built" (Eriksson et al., 2004, p. 394). As we see in Figure 5.2, there are three domains to be supported for creative collaboration: informal networking, the team space for shared expertise and the management of known knowledge. Each piece of knowledge, regardless of the origin (ideas, insights or information) is a contribution by a participant to the collaborative task. Once presented, this contribution could be traced (verbal text, written text, graphic or gestural expression). Each participant generates ideas in a distributed manner, and a system is needed to support this distribution geographically or temporarily. In addition, the system allows the free-association to produce a knowledge-based networking, in which the community is involved and participates adding, commenting or selecting ideas.

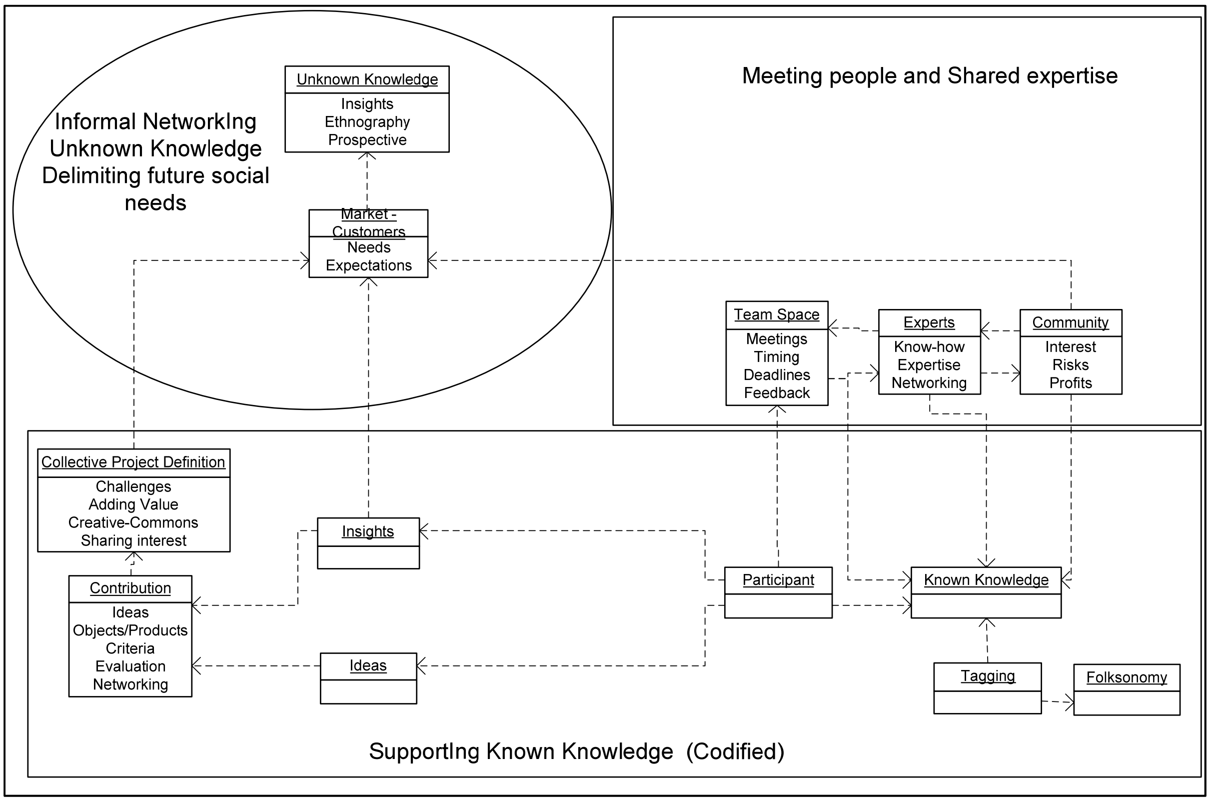



Figure 5.2 Description of general context for creative collaboration support

## 5.2 Modeling the Platform according to TRIZ

As mentioned in Chapter 3, Section 3.6.2, regarding the ideality law, the ideal KMS is established by identifying useful operations, harmful operations, cost and pains. We propose the use of ICT the useful operations, according with the usefulness and value added to collaborative activities, as Formula 5.1 shows:

$$\text{Platform design} = \frac{\begin{array}{c}\sum F\ \textbf{Useful operations and benefits of ICT:}\\ \text{Networking (Generating and Building Networks)}\\ \text{Technology Watch by Internet}\\ \text{Tracking (storage) participation, ideas, and teams}\\ \text{Capturing ideation process}\\ \text{Promoting collaborative work}\\ \text{Subject proposition and ideas' visualization}\\ \text{Meetings with experts (when it is needed), Collective validation}\end{array}}{\begin{array}{c}\sum F\ \textbf{Harmful: loss of tacit information, isolation} +\\ \sum F\ \textbf{cost, pains:}\\ \text{ICT Organization: Net/System implementation,}\\ \text{Steep learning curve, Learning, Training}\\ \text{Knowledge codification cost}\end{array}}$$

Ideality Formula Application for ICT Platform of creative collaboration (5.1)

In this formula, the useful operation and benefits of ICT:

- Making explicit the tacit knowledge based on insights and feelings; and strategic decisions.
- Visualizing the personal contribution (attributing ownership)
- Integrating the portion of information or a specific interpretation of a new idea; each idea is not produced in parallel or in a synchronous fashion, and each participant produces ideas at their own pace and with their own skills;
- Creating the space for casual meetings and expert contributions are needed to develop or to detail ideas;
- Creating a sense of project, in the first steps of design the project idea is fragmented, and members failed to meet deadlines or accomplish tasks or they did not assign task to the members.
- Matching expertise and knowledge among members.

Among the undesirable factors (that have to be avoided or reduced), there are:

- The possible loss of tacit information and the isolation of the teammates
- High cost of Platform development and implementation: organizational changes, difficulties of initial learning process (Steep learning curve), and training.

### 5.3 Model of collective idea production supported by ICT

Comparing the SECI knowledge production model (Section 1.4.2) of Nonaka and Toyama (2003) with the needs of the creative teams (Chapter 4), we propose that ICTs may be useful as a complement of collaborative interaction, particularly in the cases where the team lost information or awareness of the tacit knowledge of ideas' production (oranges arrows in Figures 5.3 and 5.4).

Our thesis support the fact that ICT makes evident the tacit knowledge obtained by the interaction among users and enable the information exchanges in two ways:

- Team space: creating a free-association among participants (Figure 5.3)
- Idea space: creating an automated space of ideas and knowledge sharing (Figure 5.4)

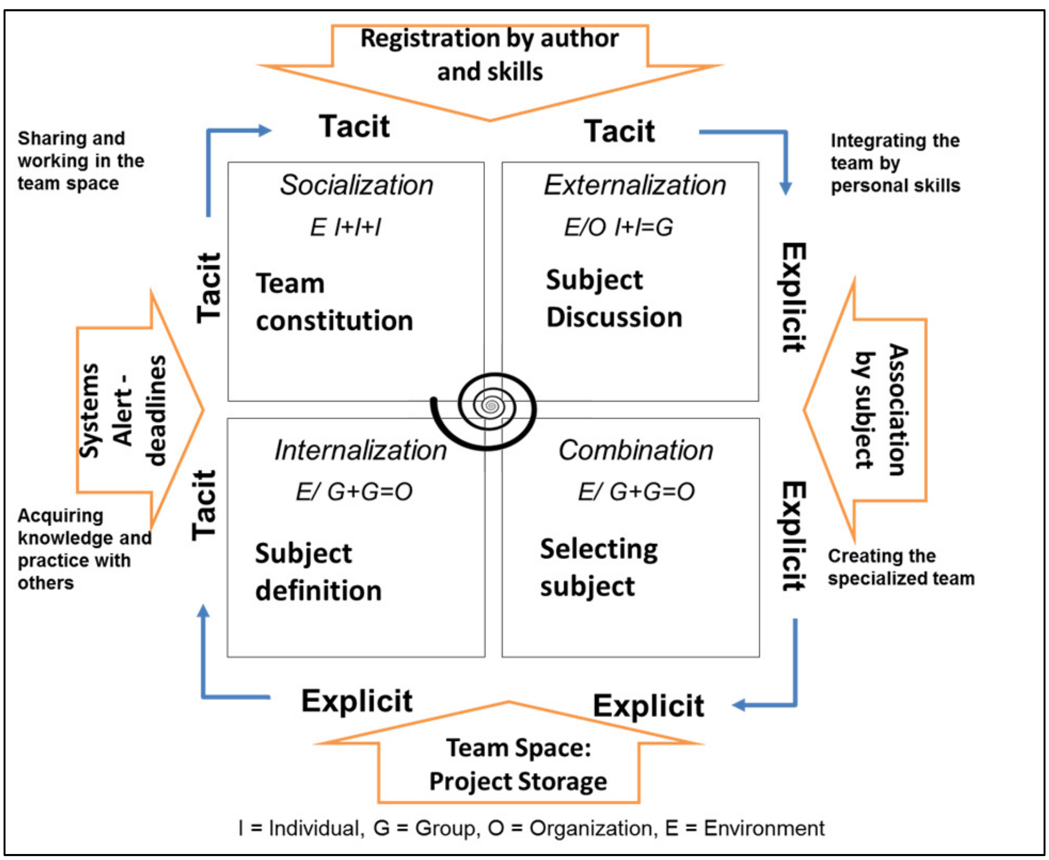



Figure 5.3 Including ICT in the team integration process

In Figure 5.3 and 5.4, as marked as part of external SECI Model, the arrows show how ICT could support the creative collaboration gathering teammates and generating a space of ideas and knowledge interaction.

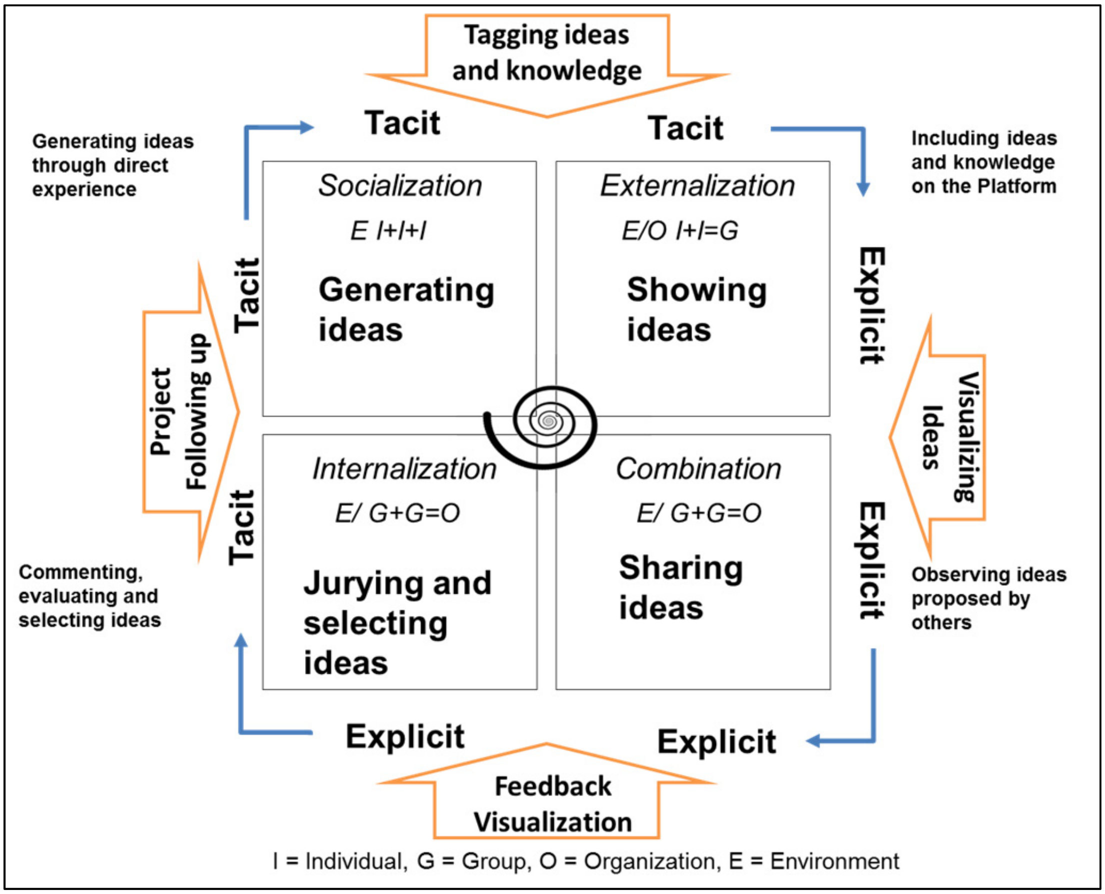



Figure 5.4 Including ICT in the collective idea generation process

## 5.4 Definition of Collaborative Platform by Use Cases

Domain Model presented at Section 5.1, defines three requirements that the system has to satisfy: 1) allowing user accesses to informal networking, 2) allowing the creative teams to share ideas and knowledge dynamically with teammates and external experts, and 3) codifying each participant contribution to be shared simultaneously with teammates. UML 2 suggests the definition of user cases according with these requirements. The use case "describes what a system does to benefit users [...] clarifying and documenting the key system needs"

(Eriksson et al., 2004, p. 57). These cases represent the main task that user has to complete to interact with its team and the system: the collaboration through sharing ideas/contributions and support this process of content creation with an automated system in which each participant has an overview of the process produced by his/her team. As result in Figure 5.5, we present five use cases presented, in which the user has to: 1) enter into the system and register; 2) contribute with ideas, data and files; 3) meet teammates, 4) tag data from Internet, and 5) follow others' contribution and the project progress.

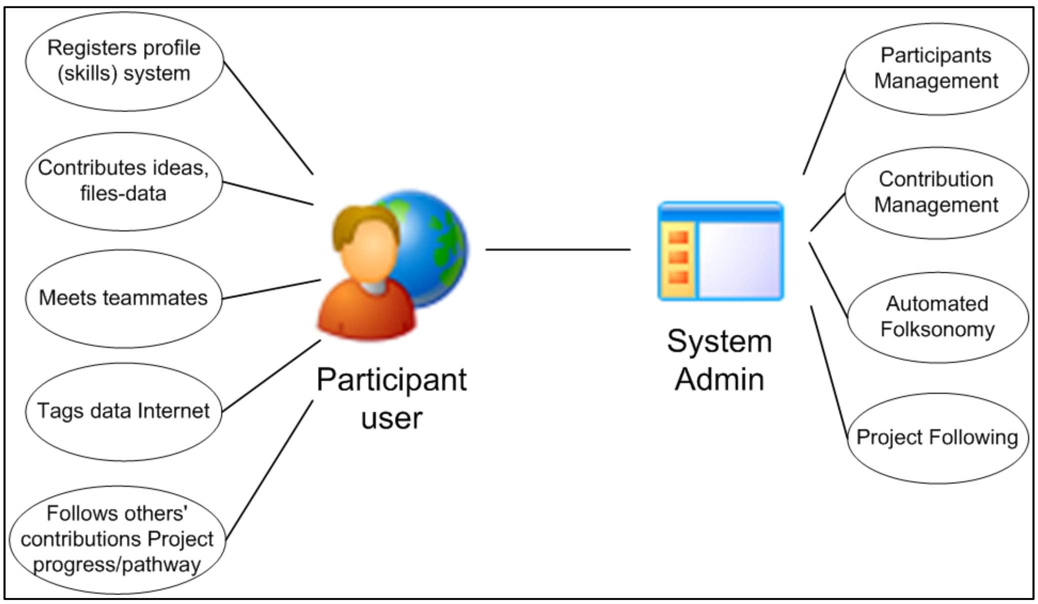



Figure 5.5 Use case overview identifying two actors: User and System Administration

The modeling of the use cases generates the following subsystems defined in Figure 5.7:

1) ***Participant Registration:*** Each participant is registered with a user profile (the user has to be clearly identified by the system and the teammates).

2) ***Team Integration (meeting teammates):*** The user can freely choose to be part of a team; or the system automatically could create the team based on the field of interest of participants.

3) ***Idea Space (Contributing with ideas and tagging data):*** the contributions are represented by posting ideas; the ideas constitute the main unit of tacit knowledge.

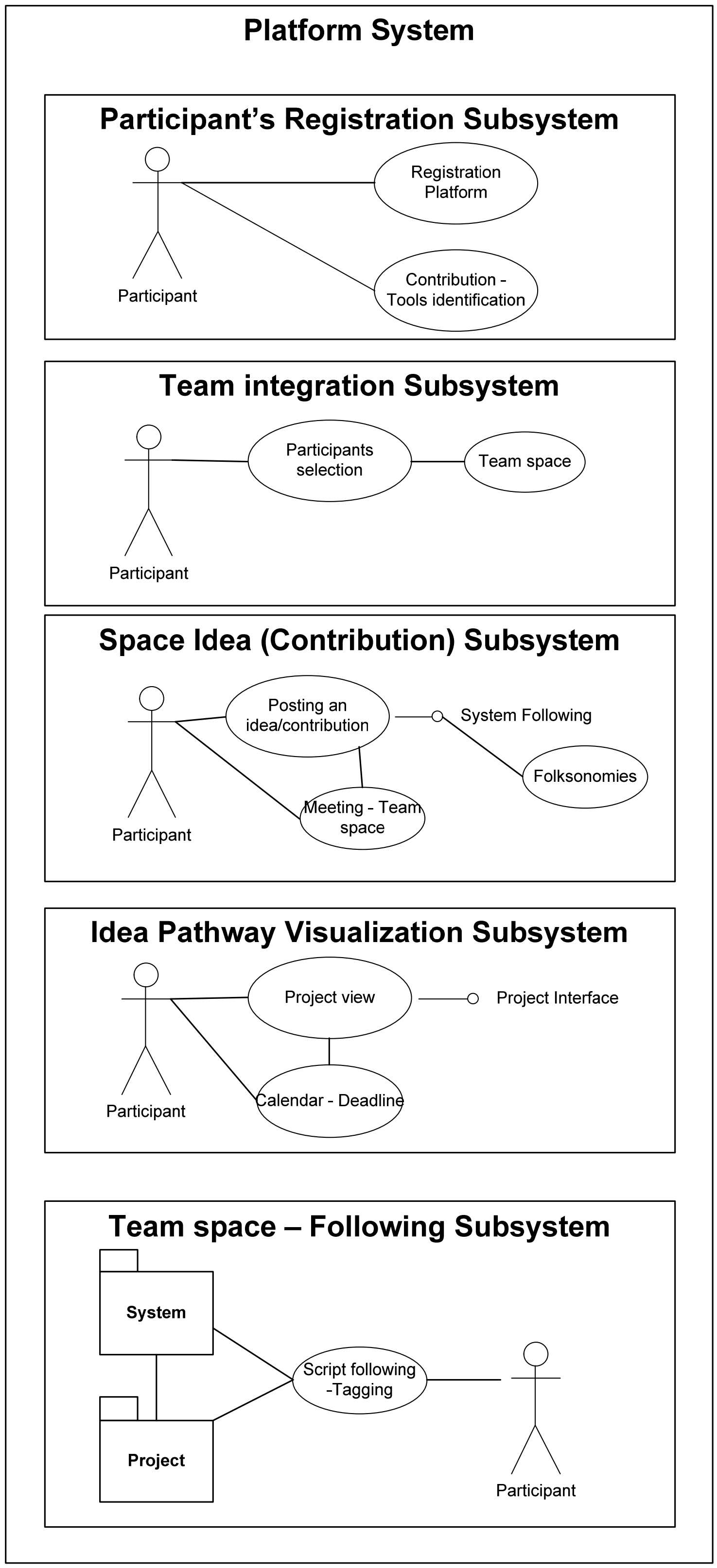



Figure 5.6 Use cases for Platform subsystem definition

The user expresses or shares his/her ideas using a meeting room, messages or images (the system has to classify this contribution by an Automated Folksonomy).

4) ***Idea and Project Pathway (follows ideas and projets):*** Ideas are integrated into a project pathway, the user identifies modifications and enters comments about their own ideas or the ideas proposed by their teammates (The system has to create the pathway for changes, modifications and a timeline that illustrate the project pathway progress)

5) ***Following the team space***: The system records and stores the ideas produced – files, images, videos, and team meetings, for sharing with others.

## 5.5 Interaction between Participant, System Administration and Familiar Tools

Figure 5.7 shows how three actors interact: the *Participant* (user) and the *System Administration* (like a database and expert system), a third object, the Familiar tools used to create content or to post, or to codify the contribution of each participant (MS Word, Paint, AutoCad, Google Docs, etc.).

Interaction between objects is realized using messages. As shown in Figure 5.7, the open arrow represents an asynchronous message and a closed arrow means a synchronous message. We observe in ICT use dynamics (Chapter 4) that there is a limit in the sharing of contributions using personal or individual licensed software. When a piece of software or groupware is easily accessible to the entire team, changes are made by each participant. However, that is not commonly the case, because sometimes, specialized 3D modeling software or video creation or editing requires expert skills from someone in the team. In that case, the team generally prefers to use a cloud application or a visualization strategy (screen view), allowing all teammates to see the result and “dictate” required changes to the teammate in charge.

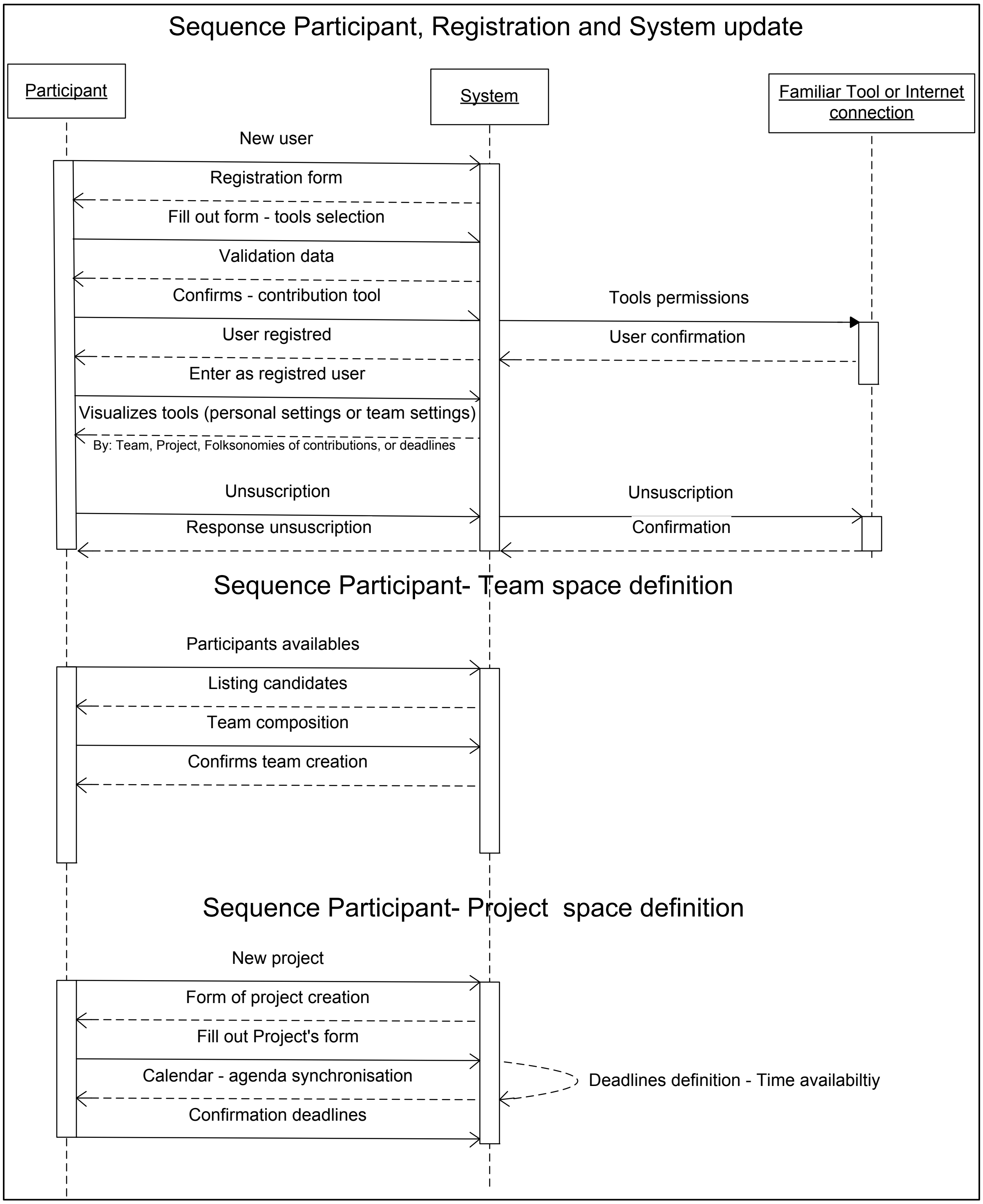



Figure 5.7 Sequence Diagrams for Platform System and users

In Figure 5.8, we observe the function to record and to store the contribution if it is produced as described above.

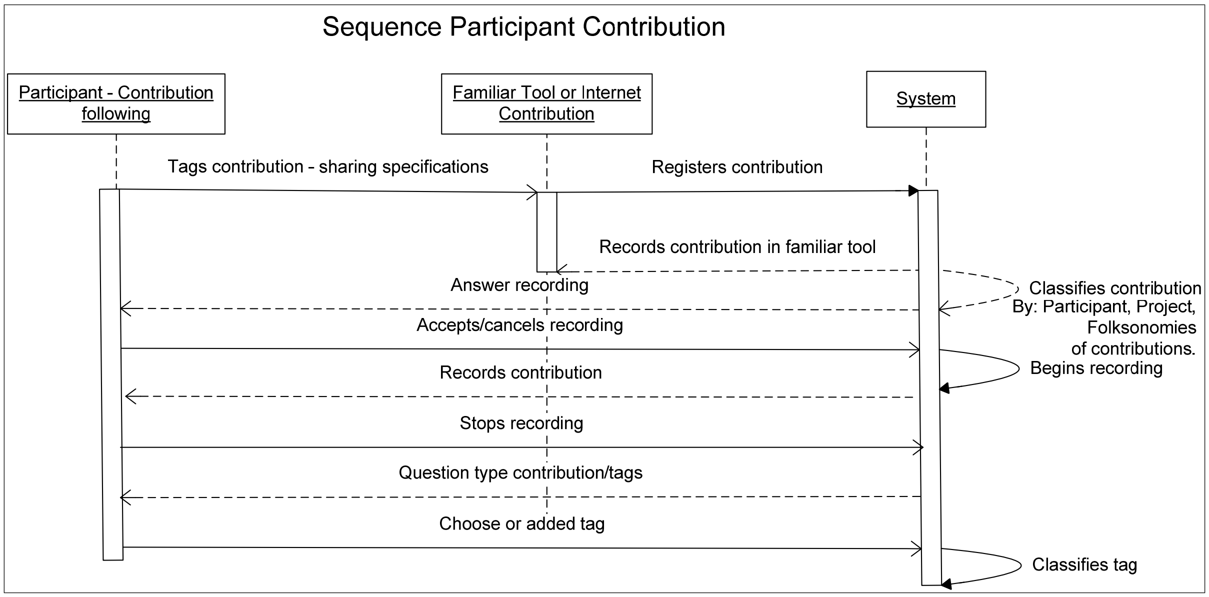



Figure 5.8 Sequence Diagram for contribution elaborated in a personal software or tool

## 5.6 Collaborative Platform Architecture

This section presents the logical architecture structure and the class diagram of the platform.

### 5.6.1 Classes and static structure of Platform

The static structure of the platform is divided into "packages, components, and their dependencies and interfaces" (Eriksson et al., 2004, p. 254). A class is distinguished as it defines a series of activities that must be structured and organized in order to establish all system interactions. In Figure 5.9, we observe the main classes describing the entire Platform and all needed interfaces. The relationship is marked with a diamond: a white diamond at the end of the line means a relationship of association between objects, and a black diamond means an aggregation relationship. These elements are symbolic messages that do not influence the systems, but rather, only add information.

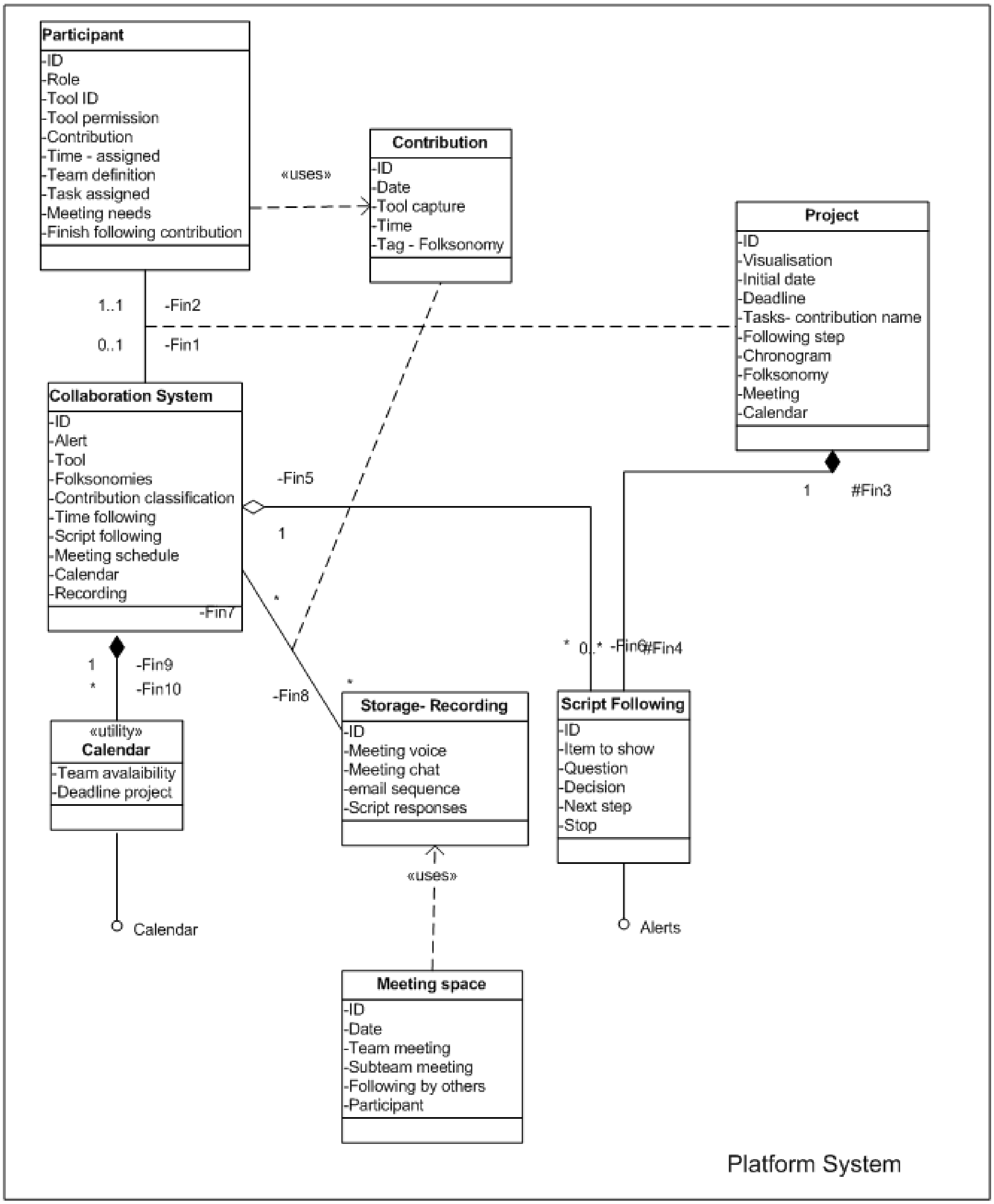



Figure 5.9 Platform Class Diagram

## 5.7 Architecture Analysis

After analyzing the main use cases making up the whole system, the logic of use cases define a structural division between the structural components and the use cases (subsystems analyzed in Section 5.3).

### 5.7.1 Package components of Platform

The Platform design includes seven packages:
1) Participant Management (Figure 5.10)
2) Contribution Management (Figure 5.11)
3) Project Management (Figure 5.12)
4) Tool permission for external contribution and shared use of individual software (Figure 5.13)
5) Tagging System (Figure 5.14)
6) Folksonomy Management (Figure 5.15), and
7) System Administration (Figure 5.16)

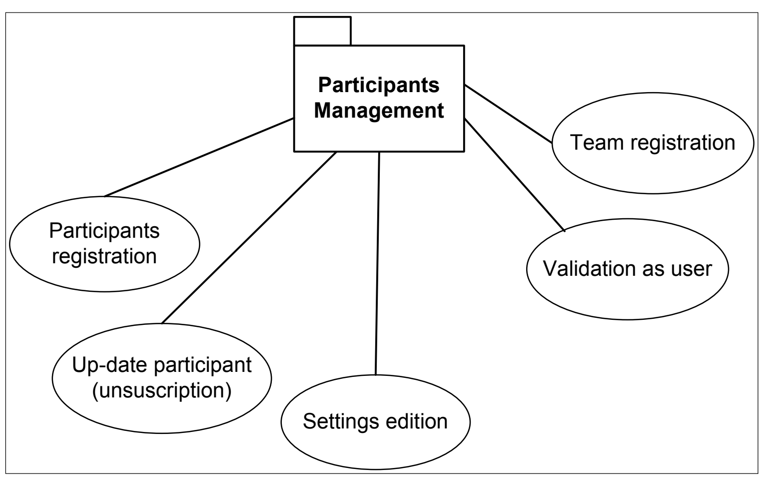



Figure 5.10 Participant Management System

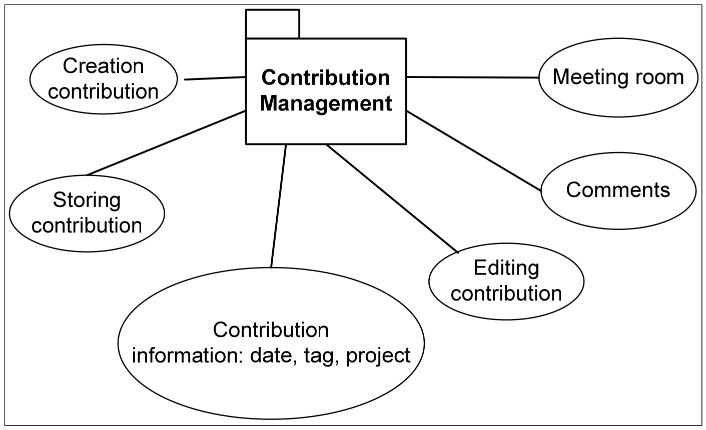



Figure 5.11 Contribution Management System

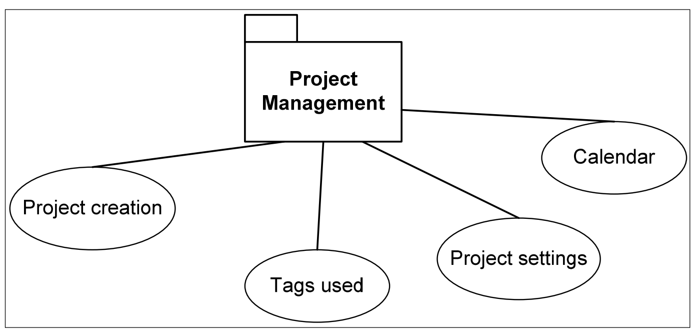



Figure 5.12 Project Management System

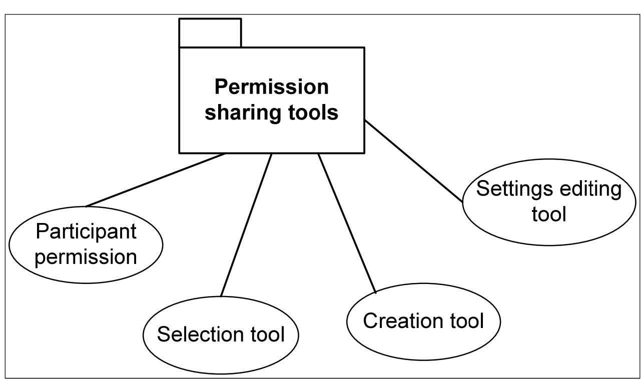



Figure 5.13 Permissions sharing tool – enhancing external tools

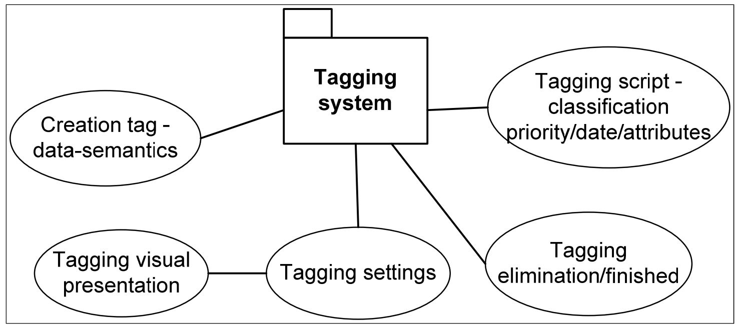



Figure 5.14 Tagging System

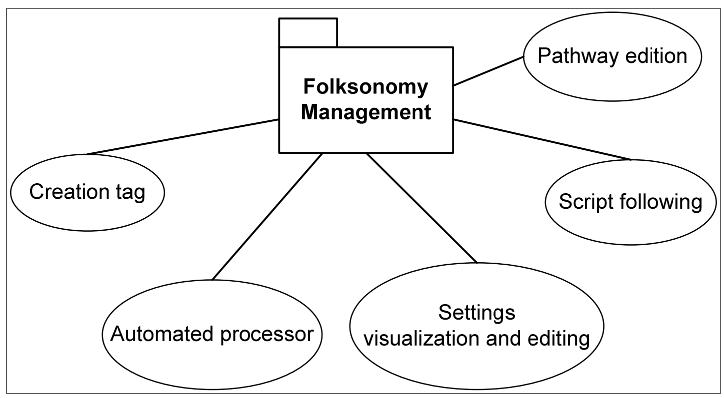



Figure 5.15 Folksonomy Management System

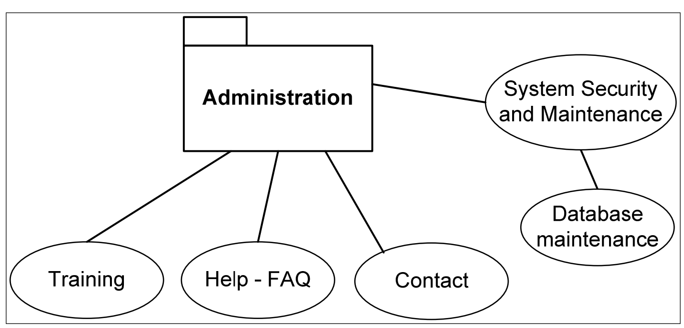



Figure 5.16 Platform Administration

These packages are articulated by two main actors: user-participants of creative teams and the Administration System, who can register, record, automatically follow, and store data that generates an automated project follows-up.

### 5.7.2 Architecture

In the design of the creative collaboration Platform, we propose an architecture based on a cloud computing system, as shown in Figure 5.17. The platform acts as a cross-platform (description in Section 6.3) because it integrates web-based applications with desktop software to enable the accessibility and the flexibility to share personal contributions.

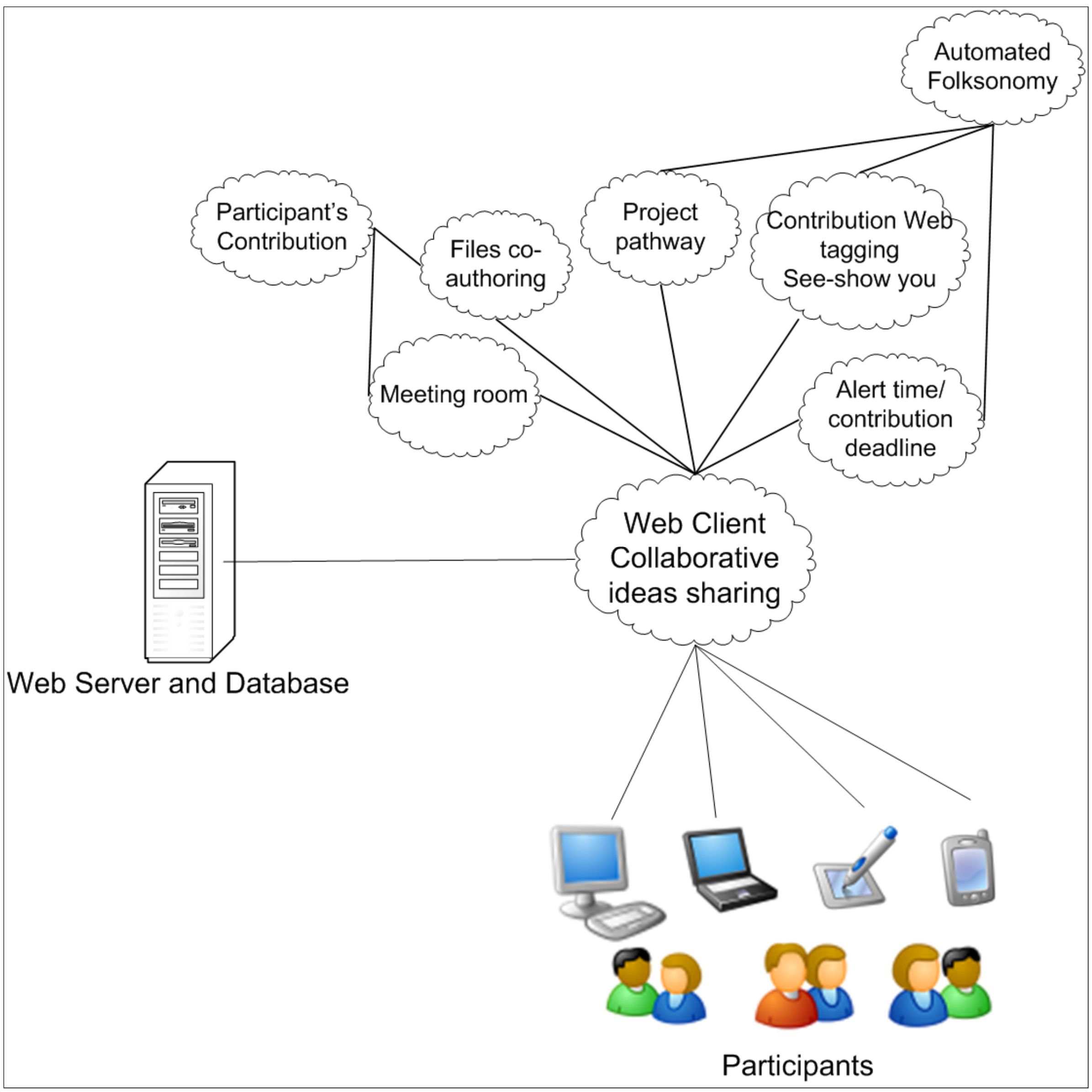



Figure 5.17 Architecture of Collaborative System

## 5.8 Addressing the Requirements of the Platform

The requirements of UML 2 are derived from the analysis of use cases; a requirement "is a user-specified criterion that a system must satisfy. Taken together, the requirements associated with a proposed system define the behavior and functionality required by the users of that system" (Rosenberg and Scott, 1999, p. 122). Different types of requirements exist, including *functional, data, performance, capacity and test* (ibid). Requirements must be differentiated from functions, which are operations of the system or the use cases. For the design of the Platform, the requirements are given below.

### 5.8.1 Functional requirements

The functional requirements "drive" the design of the Platform (Eriksson et al., 2004). The system must be able to perform the following collaborative actions:

- **Identification of users and contributions**
  - Identify users and describe its contributions

- **Meeting space and communication tools**
  - Meet other users and know about their contributions
  - Let users produce new information: messages, documents and alerts
  - Exchange information between users in synchronous and asynchronous ways

- **Capturing contributions (ideas, changes, contributions) in the team space**
  - Visualize ideas as objects of knowledge
  - Capture the contribution (ideas space, ideas evaluation, ideas comments)
  - Display the information captured in digital media (post-it or signal)
  - Express the evaluation of the contribution

- **Producing feedback or awareness of collaboration**
  - Produce teams and space for teamwork (collective contributions)
  - Highlight the contribution (ideas, comments, evaluation) of each one to another user
  - Visualize the participation of members and the alerts of system

- **Following changes and time periods**
  - Time the process (timeline or deadline)
  - Provide an user performance record (quantity of contributions, teams' participation, project participation, time spent, use statistics)

- **Categorizing information, ideas, contributions**
  - Create a dynamic of sharing
  - Integrate idea content in a Folksonomy

### 5.8.2 Data and capacity requirements

For data exchange, the system must:
- Be multilingual, and be adapted to personalized language, and all operating systems
- Use plug-ins to work in desktop or cloud mode
- Be compatible with mobile computing

Among capacity requirements, the system must be able to:
- Host small teams (1-5 users) and large teams (more than 5) with synchronous spaces (e-rooms or Web conference systems) and with asynchronous spaces (chat or sms)
- Store files by user and display information by team

### 5.8.3 Interface requirements

- Display time and timeline of idea evolution
- Display modifications or changes by each contributor

- Display meeting time and deadline of presentation

### 5.8.4 Security and privacy

- Each user must be identified, as well as their contribution
- Each team space must be private for the team
- Participants must decide with whom to work
- Participants must know that the ideas will be seen or edited by other participants
- Participants must agree to share their contributions
- The system must provide security for all users

## 5.9 Summary

The Ideality Law is a part of TRIZ methodology that foresights the ideal conditions that a system has to obtain to respond satisfactory to all users' request (an ideal state). The Ideality Law summarizes useful functions of the system (analyzed of the team's needs) in contrast with the wasteful or harmful operations; this comparison produces a new approach focus in the functions that have to be developed for the collaborative platform. This Chapter also presents the Domain Model of the research problem. The Domain Model delimits the scope of the platform in three levels: 1) the definition of the interaction among the Informal Networking to acquire unknown knowledge from the community, 2) the need of meetings spaces to interact with experts, and 3) the exchange of codified knowledge.

The platform is modelled by UML 2, which allows a description of the Knowledge Management System that provides support for the idea sharing process, the meetings with external experts and the interaction with an informal network. UML 2 leads to a simplification of specifications, and the process prevents errors due to excess information or from exceeding the scope of the Platform. In the next chapter, we give a detailed presentation of the functionalities observed in Web 2.0 and Web 3.0, as well as the new functionalities to be developed to enrich collaboration inside a collaborative platform.

# CHAPTER 6

# ICT SPECIFICATIONS AND PROTOTYPE DEVELOPMENT

In this chapter, we define the main ICT specifications (obtained from the functional requirements in Section 5.7 of UML2 Modeling) that the collaborative platform must provide to enhance creative collaboration among users in their distributed activities. We compare the current ICT tools with the new functionalities that should be developed to enable the collaboration and the project follow-up. The new functionalities proposed are: 1) Generating a team space by free integration, 2) Generating an Idea space (contribution management, evaluation and follow up, 3) Generating automated functions for project pathway visualization: tagging system and graphical folksonomy. At the end of this Chapter, we also describe the development of the prototype.

## 6.1 Current collaborative tools in Web 2.0 and Web 3.0

In an early stage of design, some ICT tools are proposed during "electronic brainstorming" based on computer or software interfaces. In the early nineties, brainstorming sessions took place in meeting rooms, chats or messaging systems. Currently, some cross-platforms based on diagramming are used to express ideas in the form of interactive mind-mappings, such as LucidChart and FreeMind (the content is produced online and is easily shared among teammates). Other tools, such as online conceptual maps, for example, including CMaps Tools, and desktop software like XMind, Brain 7.0 also exist. While such ICT tools allow the communication of ideas, there are however no appropriate following mechanisms to define advances, changes or why an idea was refused.

In the following paragraphs, we are going to describe other collaborative applications based in Web 2.0 and web 3.0

### 6.1.1 Collaborative platforms based in Social Media

Social media and the functionalities of Web 2.0 constitute an important tool for information sharing and collaboration. McLoughlin and Lee (2007) describe the appropriate use of Web 2.0 for collaborative projects or academic purposes. They define the following Web 2.0 functionalities as indispensable for achieving a collaborative project: “searching with search engine, collecting and sharing in social repositories (Flicker, YouTube), exchanging with mail and chat, using publishing tools (wiki, zoho and Google documents, Vyew and forums), presenting, reflecting and monitoring with co-drawing tools (Vyew, Gliffy), giving tasks, assembling information with blogs”. Based on this interaction, which resembles what happens on Facebook, some platforms, such as Lumiflow, TeamBox, RedLine and BaseCamp, have emerged. These enable users to share comments and files through social media, and practices which are generally embedded in the routines of students and employers. Hendler (2009) affirms that it is rather risky to define a radical difference between Web 2.0 and Web 3.0. However, currently, Web 3.0 incorporates two main functionalities: the first, the integration of data resources in a Semantic Web, as “key enablers are a maturing infrastructure for integrating Web data resources and the increased use of and support for the languages developed in the World Wide Web Consortium” (p. 111). The second one is the integration of Semantic Web language, which “allows for the assertion of relationships between data elements, which developers can use, via custom code or an emerging toolset, to enhance the [Uniform Resource Identifiers] URI-based direct merging of data into a single [Resource Description Framework] RDF store” (idem).

This capability of integrating data enables the new Web technologies to generate new applications, such as the Cloud Computing Technology (CCT), “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” (Mell and Tim, 2011, p. 2). The essential characteristics of this technology are “on-demand service, broad network access, resource pooling, rapid elasticity, customized service” (idem). CCT includes the use of Web applications such as “Software-as-a-service SaaS [e-mail, virtual desktop, communication, games], Platform-as-a-Service PaaS [Execution runtime, database, Web server, development tools] or Infrastructure-as-a-service IaaS [virtual machines, servers, storage, load balancers, network]” (idem, and examples between brackets taken from Wikipedia.org). These cited characteristics of CCT allow this technology to serve as a common information space available to all teammates.

### 6.1.2 Current open-collaborative crowdsourcing platforms

Open Innovation models include crowdsourcing-based platforms. New such platforms simultaneously support all actors of the innovation process, including designers, stakeholders and investors distributed around the world. The platforms allow new scientific development and new sources of interaction for R&D and scientific enterprises (DiPietro, 2012). “Crowdsourcing may be defined as the act of outsourcing tasks that are traditionally performed by an employee or contractor to an undefined, generally large group of people or community (a crowd) in the form of an open call. The open call may be issued by the organization wishing to find a solution to a particular problem or complete a task, or by an open innovation service provider on behalf of that organization” (Davis, 2011, p. 1). Some examples of crowdsourcing platforms are InnoCentive.com, OpenIdeo, Challengepost, y2.com, Topcoder, idea.me, and 10000Ideas. While all these platforms have promising advantages in external communication and community training, they are however mainly designed for competition, and as such, do not lay emphasis on collaborative functionalities for sharing or exchanging ideas between teams. Enterprises use these platforms to search for expertise, post challenges or present projects to sponsors.

## 6.2 ICT Specifications in collaborative platforms

For designing collaborative platforms, Germani, Mengoni et Peruzzini (2012a) propose different tools to support collaborative interactions in more advanced project development (Bititci et al., 2012; Keevil, 1998; Mengoni et al., 2011; Nof, 2007; Wallin et al., 2011). The following summary presents the main collaborative interaction:

> "– To provide basic inspection and modeling functions to analyse the product thoroughly (i.e., rotate and manipulate CAD models, zoom, measure specific model items, add or delete some parts) according to CAD-based tools.
> – To realise real-time collaboration to create a common workspace by exploiting a client–server approach (i.e., shared visualisation, event synchronisation)
> – To organise, collect, retrieve and share information and data properly (i.e., activity planning and workflows), managing team structure and roles according to a [Product Life-cycle Management] PLM approach.
> – To support product evaluation by adopting multiple product representations (i.e., functional product views and interactive Digital Mock-ups (DMUs) and integrating specific software simulation toolkits.
> – To promote and support decision-making and creative design (i.e., brainstorming and proposing) by adopting Web 2.0 tools.
> – To allow efficient interaction with different product/process representations and involve team participants in product models with interaction styles like physical prototyping by exploiting recent VR-based technologies and devices to enhance interaction and involvement" (Germani, Mengoni and Peruzzini, 2012a, p. 3)

Nielsen (2012) summarizes the current state of Web 3.0 interactions, analyzes open source collaborations, and identifies "four powerful patterns that open source collaborations have used to scale: (1) a relentless commitment to working on a modular basis, finding clever ways of splitting up the overall task into smaller subtasks; (2) encouraging small contributions, to reduce entry barriers; (3) allowing easy reuse of earlier work by other people; and (4) using signaling mechanisms such as scores to help people decide where to direct their attention" (p. 48). All these Web 3.0 functionalities integrate the information and knowledge that creative teams need for sharing. As mentioned by above authors, communication tools are essential to achieve the collaboration; however, we propose to complete the collaboration process wiht two new ICT spaces:

- The Project pathway: generated when the system tracks and classifies the contribution of each participant while the team interacts.
- The Personal idea space: generated by adding personal contributions (ideas and knowledge about the project) that are tagging by the contribution of each participant around a subject

In this chapter, we summarize the considerations to design new functionalities in Table 6.1. We will describe the functionalities to be developed in the following sections.

Table 6.1 Current technologies of collaboration and new functionalities to implement

| Knowledge Objects | Use Cases | Classes | Packages | Current technologies | ICT Specification |
|---|---|---|---|---|---|
| **1. Problem definition: abstraction of information to define the new product** | ***Participant Registration*** | Participant | Participant Management | ✓ | Identification System and Log in |
| | ***Team Registration (Integration)*** | Collaboration system | Participant Management | ✗ | Team space (each team give a name) |
| | | Meeting space | Permission sharing tools | ✓ | eRoom<br>Video conference |
| **2. Information inputs: needs, expectations, dreams**<br>**3. Ideas proposal: possible ideas that could solve the problem** | ***Idea Space*** | Contribution: ideas and knowledge | Contribution management | ✗ | Ideas - Contribution |
| | | | Tagging system | ✗ | Idea/contribution description<br>Name of idea |
| | | | Folksonomy | ✓ | Automated script tracking ideas by content or data |
| **4. Defining requirements: criteria definition based on initial inputs** | ***Idea and Project Pathway*** | Project: contribution storage and organisation by a folksonomy | Contribution Management | ✗ | Ideas Contribution<br>Presentation of ideas |
| | | | Project Management | ✓ | Task assignation, project planning |
| | | | External contribution | ✗ | External comments provides by sponsors and public |
| | | | Folksonomy | ✓ | Automated script of following ideas |
| **5. Idea elaboration: representation of ideas with details to be realized in a real situation** | ***Following the team space*** | Collaboration system | Project Management | ✗ | Team space<br>Adding team members |
| **6. Interactive evaluation: each new element added is assessed to accomplish with all criteria** | | Calendar | Administration System | ✓ | Calendar Apps |
| **Convention:** ✓= Existing technology ✗ = Non-existing technology | | | | | |

### 6.2.1 Communication Specifications

One of the most important factors to reach collaboration is communication. Stempfle et Badke-Schaub (2002) argue that “communication provides a prime access to the thinking and problem-solving process of design teams”. Human communication has two modalities: verbal and non-verbal. Verbal communication is related to the oral and written language, and non-verbal communication is related to gestural and graphical language. R&D uses both of these communication modalities (Jiménez-Narvaez, 2010). Real-time communication is essential for regular meetings and for “tuning up” moments, in which the team has to define critical aspects of the new product (first ideation stage and pre-definition of a project development). Further, there is a need for awareness of the online co-presence feeling, which requires Messaging or Instant Chat and some icons that allow users to be aware of teammate presence. ICT-mediated communication is also enriched with “emoticons”; an emoticon is basically non-verbal information presented graphically. They were designed to express the states of mind or mood of participants. Generally, emoticons are pictograms which give cues to complete textual information and to put the receptor of the message in context (Walther, 2001). Emoticons are also used to show the role of a participant and the kind of presence in a virtual space.

ICTs allow two types of communication: synchronous and asynchronous. Synchronous communication is real-time communication obtained by VoIP (Voice over Internet Protocol) voice and video streaming (Web Conference) technologies. Asynchronous communication is related to text messages that are sent with a time gap. Email, chat, discussion forum, comments and blogs are an example of this communication, which that is time-shifted. As mentioned in Chapter 3, regarding the research problem, one of the first drawbacks is the lack of technology to integrate several already available good applications to communicate ideas. In the following sections, we will analyze the main functionalities needed in designing a collaborative ICT platform.

### 6.2.2 Real-time Communication (synchronous)

#### 6.2.2.1 Verbal Communication

- Enable voice emission/reception (Desired need: video screen )
- Enable verbal peer-to-peer interactions
- Enable verbal interactions with the whole team
- Share comments (texts)

#### 6.2.2.2 Graphics

- Sharing whiteboard
- Sharing drawings

### 6.2.3 Offline communication (asynchronous)

Offline communication is essential for adding personal information and advancing tasks among members

#### 6.2.3.1 Asynchronous Verbal Communication

- e-Mail (comments)
- Message service
- Chat
- Forum
- Notes (Post-it)

#### 6.2.3.2 Graphics:

- Board or Whiteboard

- White pages, graphic files, images, photos or sketches

### 6.2.4 Sharing knowledge objects (codified knowledge in files and/or contributions)

The members announce when they have an idea: “My idea is”, “I have an idea”, “I think”. The contributions need to be evident or shown; it is generally an invitation to see-show what I see or I think.

- Share Web links
- Share files created in standard/specialized software
- Share comments (verbal – dictation or texts)
- Share notes
- Share other elements as photos, videos, renderings, sketches, etc.

### 6.2.5 Explaining Ideas – contributions visualization

Finally, the ideas appear by work time periods, and are attached to a context (semantic knowledge or project stage-task).

- Markets, tags or alerts
- Idea description

### 6.2.6 Idea Evaluation, Questions, Criteria/Restrictions or Decisions

An important part of the collective idea production process is the addition of structured information or elements to validate the information

- Marking elements for decision (scale matrix for decision evidence)
- Notes or comments
- Agreement tags (emoticons, scale)
- Justification (text, contribution or speech)

### 6.2.7 Ideas space and interface (conceptual space)

Participants miss deadlines or timing, because they are not easily informed of the project evolution. They need:

- Visualization of ideas (by date or time posted, by author, by project subject or tag)
- Visualization questions in advance

#### 6.2.7.1 Visualization of Idea Evolution pathway

- Visualization changes (changes elaborated)

#### 6.2.7.2 Visualization of Decisions

- Visualization of elaborated/final version

### 6.2.8 Personalization (personal space, authoring)

The idea-attribution or property seems to be an important factor in contribution. Although collaboration implies an implicit collective work, the authoring process – idea identification – is an incentive to participate:

- Idea identification (by author, paternity or ownership)
- Change pathway (by decision-author)
- Questions or misunderstanding (directional from the author to the teammates)

### 6.2.9 Team space

Absent participants need references and clues to be aware of their team's responses and task progress; some important elements that may be used:

- Where we are? Visualization/Deadline alerts
- What's up? (News/ changes)

- What do I have to do? (Assignation tasks)
- When can we talk? (Calendar meetings)

## 6.3 Dynamic of creative collaboration in a cross-platform

We have completed a review of current communication tools, and now we would describe the proposed cross-platform and its new funtions. A cross-platform is an embedded system that has the capacity to support software in a large variety of hardware configurations (Huifeng and Lijuan, 2010). Popular cross-platforms include Skype® and ooVoo®. They can be installed on mobile devices (iPod®, smart phones or Android®) and on a desktop computer. Usually, these applications require the installation of a plug-in, and the user could find an associated tab for them on their desktop. Cross-platforms also support updates, combining desktop information with cloud information, as is the case with DropBox®. DropBox® has an automated connection between a folder on each user's desktop and a cloud folder, which is updated with each new shared file.

The use of a cross-platform can facilitate peer-to-peer or team collaboration, in showing information captured from the Internet and ideas produced in a familiar application (for each participant) or obtained through a Web-conference. Each one of these information inputs is a contribution that must be observed by all teammates. If a contribution is shared, the plug-in installed enables the "next system" script to codify all the contributions. Automatically, in a "cloud interface", each user can observe the track of contributions generated around a subject. The contributions are classified by ideas, questions, notes, comments and decisions. The system enhances all these data in a cloud-tagging system that allows the visualization of the process for each team participant. The participant could then select with whom they want to share and for how long, thus delimiting the project pathway. All this information can be visualized on a desktop model, such as a Drive or Google desktop interface or as a cloud page, similar to DropBox – Web page for managing folders. The basic user interface is similar to touch screen interfaces – offering a home screen navigation and some buttons to tag contribution information. The system records the data, the time and with whom the user had an interaction.

### 6.3.1 Team Integration and Team Space

In the cross-platform each member could be part of a team, and he/she could participate with ideas and known knowledge. Being part of the team means sharing the same cognitive space and being aware of the ideas and knowledge produced by the others members. The ideas are produced as comments (verbal or written) or drawings. Also, the participants could provide information, knowledge or Web links meaning the tagging system. All contributions are tracked in a shared space for the team. In this cross-platform it is the tracking system that produces the sense of the project. By following each contribution by participant, we can view the team space inside the cross-platform as a whole system organized by time (as a Web Page or Interface). The Platform system generates an automated symbolic representation of the Project Pathway as seen in Figure 6.1. (In the following Figures, the icons are used as indicative support; original icons belong promotional material of Cegedim software firm, 2005)

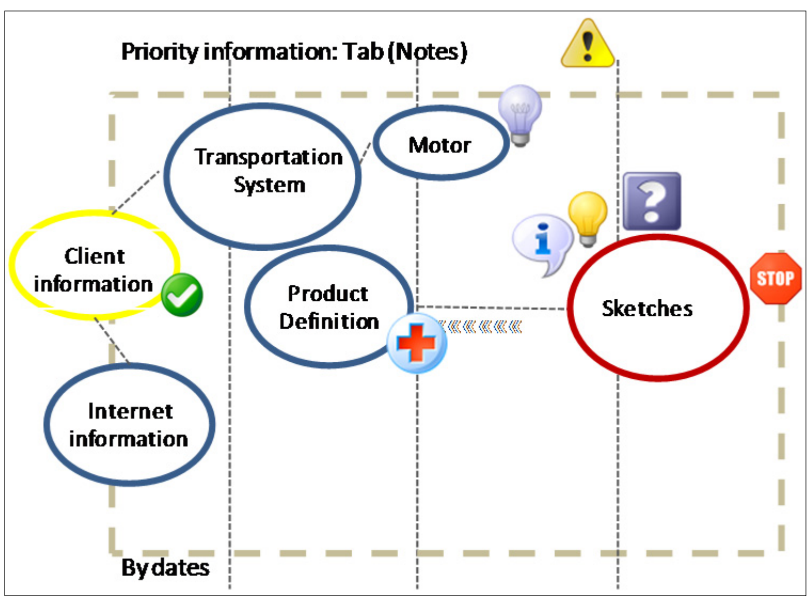



Figure 6.1 Project Pathways represented on Platform

Participants should be able to easily identify the part of the project the team is in. Moreover, in this space, the participants find some clues or alerts to know what the state of the project is and contribute in specific subject (as well as the priority by deadlines). The size of each circle corresponds to the number of contributions and the color is shown by priority (yellow - past, blue - in transit, and red - to do). If a participant/teammate needs more information about the knowledge and the ideas proposed by their teammates, they can click under an icon or bullet, which contains information, and they can answer with a comment, as presented in Figure 6.2. Figure 6.2 also shows a visual example of what is inside the balloons.

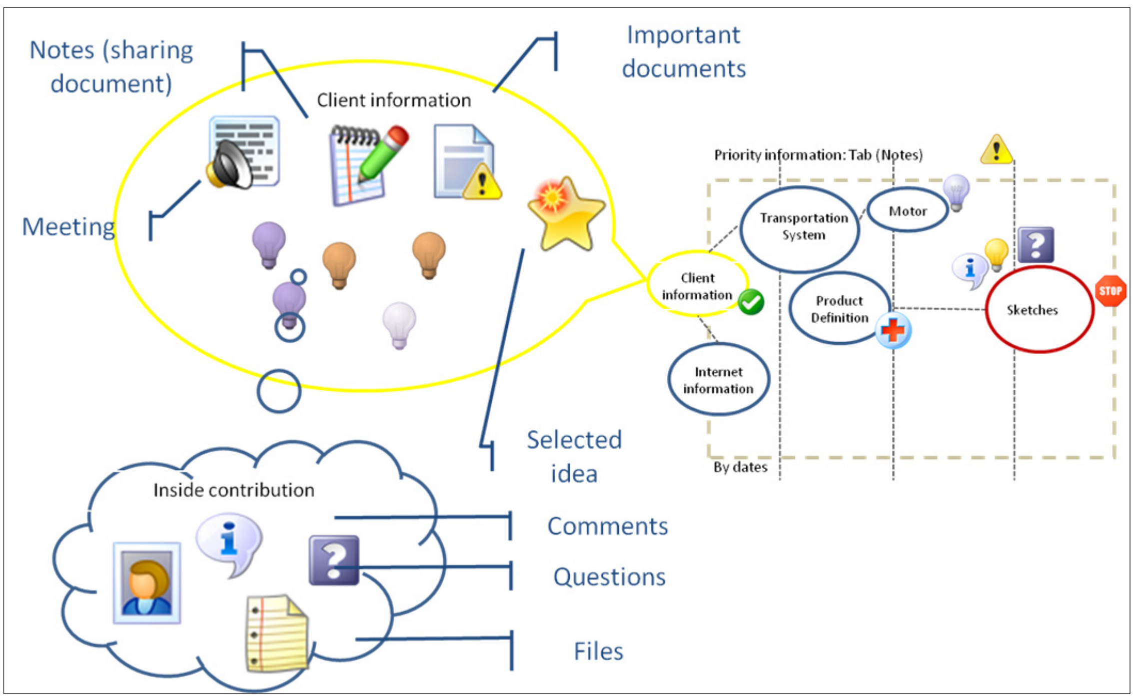



Figure 6.2 Deployment by contribution and inside elements

### 6.3.2 Personal idea space

In this space, the system summarized the priority information that each participant has to know and their personal contributions. The personal space is formed by each personal contribution (I have an idea or something to show) and the history of contributions (Internet links, post or files presented to the team). The participant can see the last information or pathway of the project, as well as the task to do, as a list of "things to do" (see example in Figure 6.3).

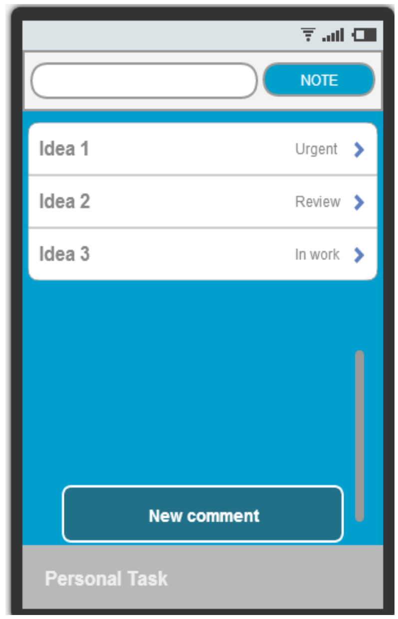



Figure 6.3 Personal Space Interface

### 6.3.3 Project Pathway

As example, we could observe in Figure 6.2, the effect of clicking the yellow balloon, the participant can view the notes, images, sketches or links tagged by the other participants. Each of these posts could be shared in anonymous mode (no owner identified), or authoring mode (author identified), according to organizational decisions. The tag also includes the part of the project and the “key word” assigned to the contribution. Figure 6.2 contains the terms *client information*, *transport system*, and *motor*. The word that identifies the assignation of the task or the contribution of a participant and each teammate is considered a “spark” which was used as the basis for the task or contribution references.

## 6.4 Enriching collaboration: Graphic Folksonomy and Collaborative Tagging

The use of ICT tools fosters a new enhanced treatment of generated content by a social interaction. That is the case of Folksonomy, considered as metadata created gradually by a community. The metadata is generated by each participant’s information needs, and brings links or interactions that facilitates collaboration among participants. Sinclair and Cardew-Hall (2008) affirm that “a key characteristic of the Folksonomy is that it is *user created metadata,* that is, the people who use the system are also the ones tagging items" (ibid, p.17). This kind of information treatment is important within a pre-project (ideation stage) because each participant confers a meaning to their creative contribution in a social context. Some examples of Folksonomy classification or metadata sharing are available at [www.socialtagging.org](http://www.socialtagging.org), as see at Figure 6.4:

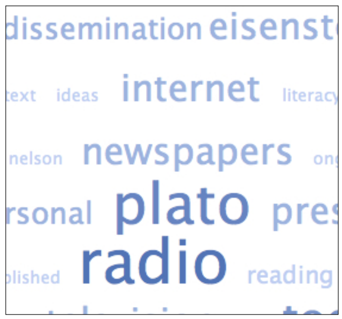



Figure 6.4 Cloud-tagging Folksonomy
Image retrieved from: http://designbit.co.uk/2010/10/10/difference-between-taxonomy-and-folksonomy/

This interactive visualization could be extremely useful for classifying personal ideas (participant's contribution). Each participant shares a cloud space of ideas by project space (limited by time and semantics). We must remember that the name of a task or activity pertains to a specific context of teamwork. In Figure 6.4, we show a traditional cloud-tagging Folksonomy. However, we propose a graphical visualization of the cloud-contribution by clusters, as shown in Figure 6.5.

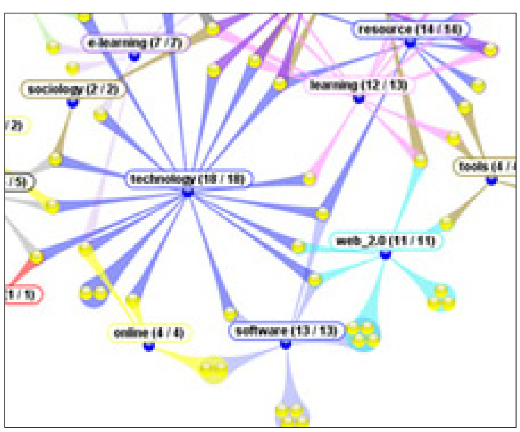



Figure 6.5 Clusters grouping knowledge by density
Image retrieved from: http://www.visualcomplexity.com/vc/project.cfm?id=706

### 6.4.1 Collaborative Tagging for supporting fuzzy production of ideas

In a virtual space, the idea might be created spontaneously by the information provided by each participant to the team. In a physical space, participants generally use post-it, notes or sheets of paper to write or draw its ideas. In a virtual space, ideas can be writing, drawing or tagging. The tag about a new idea generates metadata that has a mean for the team (collaborative executed task). This metadata produces new information that is "recording or posting" in the system depending on the "name" of the task or the activity provided by each team. Sometimes, the team gives the same name to the same task or contribution, but sometimes, each participant aggregates a new name or new variation of the same activity. This element generates a "fuzzy logic" – when the response is not true or is not false, has a multivariable response that generates at the same time a fuzzy dynamic in the tagging process.

Collaborative tagging "is the practice of allowing anyone – especially consumers – to freely attach keywords or tags to content. Collaborative tagging is most useful when there is nobody in the 'librarian' role or there is simply too much content for a single authority to classify; both of these traits are true of the Web, where collaborative tagging has grown popular" (Golder and Huberman, 2006, p. 198).

We propose five levels of tagging inside the Platform:

1) Subject worked (client or sponsor posting) – challenge selected by team
2) All concepts produced by subject/challenge/domain
3) All contributions produced by participants in a timeline
4) Participants by project
5) Client that responds by subject to all the teams with the same information

### 6.4.2 Graphical Folksonomy of ideas production

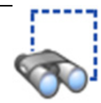
Previous research about interaction during teamwork (presented in Chapter 4), enables the understanding that each participant collaborates in a stage and in a different task within a large team. Also, when a new participant arrives, they generally prefer to go back and review the stages already completed by the other participants. We propose that the contributions and comments shared for each participant could be tagged and classified in an interactive Folksonomy. This tag classification reflects the names and the objects of knowledge delivered (ideas, products or files) inside the team. This process was studied by Folksonomy (Vander Wal, 2007), a term which comes from replacing *tax* of *taxonomy* with *folk* – regular people, and so "Folksonomy is the result of personal free tagging of information and objects) for one's own retrieval. The tagging is done in a social environment (usually shared and open to others). Folksonomy is created from the act of tagging by the person consuming the information" (idem).

In the Platform, we propose that the information retrieved from the tags of each contribution is organized in three graphical pathways: by author (personal space), by team (team space), by project (data from calendar and deadlines). Usually, Folksonomy is presented in a textual cloud-tagging, but we however propose a ***graphical cloud*** (see Figures 6.4 and 6.5) that is identified according with the number, the frequency and the significance of a tag for the group, by example the quantity of contributions of each member, frequency of revisions (timeline) by a team member, and adding some distinction to the realized tag of a user with a profile –client or –project leader. No scientific literature on graphical tagging or graphical Folksonomy is available, and so we cannot claim that using this method would lead to improve the team performance. However, we could propose this kind of visualization of knowledge because engineers and designers use it on a daily basis to work with graphs and pictograms. In knowledge or project management, engineers and designers are accustomed to using graphical tools like Gantt Diagrams or Conceptual maps. We note that the timeline of project pathway is a common form of expression, and could be used in this part of the graphical tagging, as shown in Figures 6.1 or Figures 6.2

## 6.5 Enriching ideas production by collaborative interaction

Participant's contribution (authoring): ideas and knowledge upon by tagging and are classified under following types: graphics, images, comments, and photos, files that are proposed by participants or when a team member sees some interesting information on the Internet which they would like to show their teammates. With the tag, the participant mentions the reason, the project and the “justification” of the tag, with pictograms as shown in Table 6.2. In this dynamic, participants can also comment or write a note (such as a post-it) about the tag and select a word to redefine a task or aggregate a new information tab.

Table 6.2 Explicit Pictograms for naming contributions

| **Pictogram** |  |  |  |  |
|---|---|---|---|---|
| **Meaning** | I have an idea | I have some-thing to show you | This is my fa-vorite | My comment or my note |

### 6.5.1 Awareness of teammates and ideas evolution

For a distributed team, participants need for awareness of the changes and the evolution of ideas. A practical solution in this respect, the status box, comes from social media, and is filled to describe a mood or a personal status. It answers the question: Where are we? Figure 6.6 shows the status box on Facebook. The status is presented as a tab of a comment, and is classified by time and specific contribution, and by kind of message for the entire community or for the team.

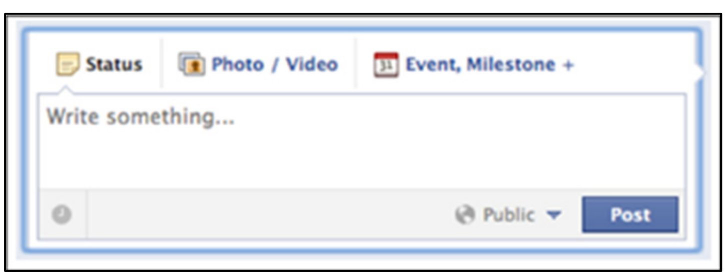



Figure 6.6 Status box for Awareness participants’ moods“Tell your friends what you’re up to” Retrieved from Facebook

### 6.5.2 Ideas questions

When a new idea appears in the team space, teammates could have questions, and these questions would generate answers as Design Objects (Section 1.2). Displaying Questions and Answers are an important part to illustrate the process pathway an idea development. In the idea space, the idea's owner can see some icons related to the reaction or feedback produced by each idea (see Table 6.3). Each participant who has a question can formulate and tag their question: 1) With a text to write a note or a comment (chat) or an icon to talk, and 2) When a participant tags a contribution with the symbol inspection, invites participants to give their opinion to team members or to a person in particular (expert evaluation).

Table 6.3 Ideas Information

| **Pictogram** |  |  |  |  |  |
|---|---|---|---|---|---|
| **Meaning** | You have a question | Information available | Writing and Voice Message | Ask for expert evaluation or more details | This is a specific criterion |

### 6.5.3 Ideas Evaluation

#### 6.5.3.1 Matrix Evaluation by Criterion

An important part of the design process is the selection of ideas by criteria proposed in a previous product requirements analysis or briefing process. We propose a somewhat similar matrix for idea evaluation in Table 6.4. With a score scale, it could be a qualitative scale with icons or a quantitative scale by numbers or by percentages decided by the team and the project requirements.

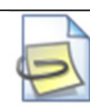
Table 6.4 Ideas Evaluation Matrix

| Ideas | Description metrics | **Idea 1**  | **Idea 2**  | **Idea 3**  |
|---|---|---|---|---|
| **Criterion 1** | Innovation index (no similar object in market) | Number/Icons | | |
| **Criterion 2** | Technology Advantages | | | |
| **Criterion 3** | Cost and Benefits | | | |
| **Criterion 4** | Ecological Aspects | | | |
| **Criterion 5** | Audience Impact and Presentation | | | |

#### 6.5.3.2 Ideas Selection Display

One special thing participants need after posting or expressing a contribution is to know the opinion of their teammates and obtain feedback. This feedback process can serve as an incentive for new ideas and collaborative changes. Table 6.5 shows a proposal for main comments, such as congratulations, notes, addition of new ideas, constraints or requirements, to be included in the feedback.

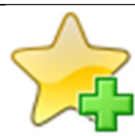
Table 6.5 Idea Selection Pictograms

| **Pictogram** |  |  |  |  |
|---|---|---|---|---|
| **Meaning** | Selected idea | Some comments or notes about my perception | Addition of ideas | Constraints or requirements |

#### 6.5.3.3 Emoticons

As explained in Section 6.2 regarding enhanced communication, emoticons constitute a special symbolic language in ICT. We propose the use of an idea emoticon related to the insight created by the idea in the teammates. This type of evaluation could be used to select an idea. In a decision space, each participant could post their idea and the system automatically organizes a vote session or a perception/insight notation. This evaluation could be accompanied by a numerical score by criteria (depending on the number of contributions and critical aspects defined), as seen in Section 6.5.3.1 or as in the next Table 6.6.

Table 6.6 Examples of Ideas Evaluation by Emoticons

| **Emoticon** |  |  |  |  |  |
|---|---|---|---|---|---|
| **Meaning** | This is my favorite idea | This idea has something outstanding | This idea should be reviewed | I like this idea a lot | Lost my good feeling |

#### 6.5.3.4 Alerts System

In collective, as well as in remote work, each participant could be absent at some stage or deprived of relevant information concerning the project. We propose an alert system allowing verification of new priority strategic information on timing, deadlines and decisions. We propose the following characteristics for system alerts:

#### 6.5.3.5 Priority Information Needed

Table 6.7 shows some examples of pictograms used to express possible information needs among participants. Specifically, we have notes, restrictions, constraints or very helpful or priority information for advancing the project. The participant could mark an alert to be displayed when something requiring priority sharing is present.

Table 6.7 Priority Information Needs

| **Pictogram** |  |  |  |  |
|---|---|---|---|---|
| **Meaning** | Constraints to review | New priority information | Priority need | Risk of stopping the project |

Moreover, other alerts could be available, related to the project advancement, including:

1) Changes in the project subject selection

2) The assessment (evaluation) of concepts

3) Decision to take or to ask to others

4) Questions to be asked or answered to clients

## 6.6 Summarizing of objects of knowledge in a Global Team Space

Figure 6.7 presents a mock-up of the platform interface. The mock-up represents a team space interface. It integrates a few functionalities into a project pathway (in a timeline) and ideas evolution (semantic context). Moreover, in the center, we have an overview of all teammate contributions. In the personal space, each member could see their personal contribution ideas, personal alerts and personal comments (sent and received).


Figure 6.7 Global Project advance interface

## 6.7 Deployment in the Platform Prototype

The prototype was developed by Clément Jacquot (2012) during his internship at École de technologie supérieure (Winter-Summer, 2012). In the prototype, the packages of the cross-platform proposed as ideal solution described in Chapter 5, Section 5.7, were adapted by technical constraints and high cost of development to a PHP (Personal Home Page, better known as Hypertext Preprocessor) System.

The Prototype was implemented as a Web Content Management System (WCMS), a "software system that provides website authoring, collaboration, and administration tools designed to allow users with little knowledge of Web programming languages or markup languages to create and manage website content with relative ease" (Wikipedia, 2012). More than 75% of Web applications are developed in PHP language including recognized applications such as Facebook, Moodle or Wordpress (ibid). The Platform Prototype was developed in PHP, with the goal of producing "dynamic" and interactive Web pages that allow the information exchange among team participants. The prototype was implemented at www.innokiz.com to be used for the 24 Hours of Innovation, May 2012, an International Competition organized by our team at École de technologie supérieure. Figure 6.8 presents a glimpse of the mock-up of InnoKiz.


Figure 6.8 Glimpse of Mock-up of Collaborative Platform prototype developed with Clément Jacquot (2012)

In Table 6.8, we present a comparison of the InnoKiz pages and the package defined in UML 2, and observed functionalities that were used by participants on www.innokiz.com. Almost all packages were adapted to a PHP system, except for the Folksonomy function, which appears as statistics, or in the way users identified (named) their ideas or contributions. This functionality was replaced by a statistics Box which could give some information of current activity in the Ideabox, as we will soon explain in the next Chapter, in Figure 7.2

Table 6.8 Comparison of use cases proposed in UML 2 and Innokiz Prototype

| **Modeling in UML 2** | | | **Task realized in Prototype Platform Innokiz** | | | |
|---|---|---|---|---|---|---|
| **Packages** | **n** | **Task reported** | **Task** | **Frequency** | **Used** | **Profile** |
| **1. Participant Management** | 2403 | Registration; Data provided CV | Completing a form Editing the Worldkiz page | Once at beginning | Yes | User |
| | 882 | Team creation | Teamkiz creation | Once for team | Yes | User |
| | 40 | Industrial challenges | Description of challenge | Once for industrial | Yes | User - industrial |
| **2. Contribution Management** | 135 | Team created | Team integration space | Once for team | Yes | User |
| | 110 | Proposed Idea | Ideabox | Fuzzy | Yes | User |
| | 47 | Team's contribution | Private comments in team space | Fuzzy | Yes | User |
| **3. Project Management** | -0- | Timing – Project delay | Alerts (comments) | (N/A) | N/A | System |
| | 110 | Idea evaluation | Quantitative evaluation | Fuzzy | No | User - industrial |
| **4. Tool permission** | | Using resume or social media | Linked accounts (Sharplinker) | Once | Yes | System |
| **5. Tagging system** | 135 | Naming ideas | Ideabox (name ideas) | Each time a new idea is proposed | Yes | User |
| | 110 | Criteria and emoticons | Ideabox (judging ideas) | Each time a new idea is proposed | Yes | User |
| **6. Folksonomy management** | 0 | N/A | | | N/A | |
| **7. Administration of system** | 114 | Users questions | Questions/Responses | Fuzzy | Yes | System |
| | 47993 | Dynamics | Comments | Competence delay | Yes | Admin |
| | N/A | Maintenance | Delete/aggregate information | Competence timing | Yes | Admin |

## 6.8 Summary

Some of the main functionalities described in this chapter are related to the transformation of tacit knowledge of an idea (contribution) into an explicit knowledge obtained by interaction among teammates. Each idea or comment is an object of knowledge, which constitutes a part of a whole system.

A cross-platform is proposed to produce a comprehensible KMS. This representation is possible when participants communicate their ideas and when they share information, comments and decision to nourish the idea in a complete creative process. In a collaborative creative process, the two ideas generation and evaluation directions are complementary.

During the study of 24H teams, it was observed that a very important part of interaction among teammates was related to Internet browsing and information search. We propose that this interaction could be facilitated by a cross-platform allowing the easy capture of Internet links or of the information pathway.

We further propose that this cross-platform should track ideas by participants (authoring), time and semantic content. Also, the platform proposal enhances the collaboration with the tagging and the automated Folksonomy that is generated by the interaction among teammates in a cloud space. The system records the ideas, and tracks the ownership and the time in the project execution.

In this Chapter, it was described the deployment of the PHP prototype –that adopts some new functionalities proposed in the modeling step (Chapter 5), such as: Team integration by subject, ideas' production and evaluation, the use of emoticons to judge an idea, and the space to adding comments or messages from external partner or community. These functionalities will be tested in the next chapter.

# CHAPTER 7

# PLATFORM PROTOTYPE TESTING

In this chapter, we describe how we tested the Platform Prototype, by means of a UML 2 testing: validation of use cases by user's acceptance and the task analysis method. We test the main functionalities and creative collaboration use cases described in Chapter 5. These elements were partially implemented in a Web Platform prototype, www.innokiz.com.

## 7.1 Study Description

We focus the study on descriptive statistics obtained in the use of the prototype and the functionalities proposed in Chapter 5 and the specifications of Chapter 6. This study was realized during the 5$^{th}$ 24H competition which took place at ÉTS in May 22 and 23, 2012 in partnership with C2MTL (Commerce+Creativity) event organized by SidLee – one of the most important advertising enterprises in Canada). It involved 17 sites distributed across all continents, and sponsored by more than 10 enterprises (sponsors of creative challenges). The teams were challenged to come up with an innovative solution to a problem presented in a three-minute video, and were then assessed by academics and manufacturers.

### 7.1.1 Subjects

InnoKiz supported almost 2403 registered users from 46 countries. 882 participants worked online within the platform (teams and site location are in Appendix II). Following an Ethical Plan approved by the ÉTS Ethical Review Board, we invited all the 24H participants to sign an Acceptance form and respond to nine online questionnaires about creative activities and the use of the Platform (see Appendix I). 267 participants agreed to participate in the research, and their professional training was distributed as follows in Table 7.1.

Table 7.1 Distribution of participants by educational level

| University degree | | n | % |
|---|---|---|---|
| Undergraduate | | **121** | 54% |
| Graduate specialization | | **29** | 13% |
| Master Degree | | **42** | 19% |
| Ph.D. | | **9** | 4% |
| Other (Professional) | | **23** | 10% |
| | Total | **224** | 100% |

### 7.1.2 Task

The entire competition planning and organization was managed from www.innokiz.com. Students are given 24 hours to create an innovative solution to an industrial problem of their choosing, which provides an experiential learning opportunity in creativity and innovation issues. Each participant had to be registered to appear as a team member or to have access to polling the ideas posted by their team or to vote for the result presented by other teams. Each registered participant had the option to enter a public (external) vote for another team, at the end of 24 hours each team has to post a video to be part of the competition.

### 7.1.3 Procedure

More than six months beforehand, invitations were sent to universities by e-Mail. Professors and students interested in participating in 24H were contacted and, one month before the Competition, were invited to test the communication system supported by WebEx™. Two weeks before the start of the competition, users were given access to remote training, and tested the Platform by creating their Team space as well as the Idea Space (Ideabox). Mickael Pallier (student from École Mines Albi, on internship at ÉTS) and the author developed a tutorial available at http://www.innokiz.com/resources.php?selectR=Tutorial. In accordance with the Ethical plan (Appendix I), the 24H teams completed a first online questionnaire which captured biographical information, project development and teamwork experience, as well as seven online forms. The forms have open-ended questions, and were sent out every three hours, asking participants at what stage of the design process they were, and what knowledge and tools they had needed and used. Participants then completed and submitted a final user satisfaction questionnaire at the end of the competition.

## 7.2 Description and evaluation of Use cases

Roger (2013) mentions "user-acceptance testing" is particularly useful for a beta testing of a new system. Table 7.2 present the statistics obtained during the interaction between all participants using InnoKiz. The next subsections explain each use case.

Table 7.2 Statistics of use of Innokiz (reported by Webmaster Clément Jacquot)

| **Uses-cases** | **Number** | **Description** |
|---|---|---|
| **Participant Registration (all registered users):** | 2403 | User registered (individual personal data) |
| | 42 | Participants role - industrial |
| **Team Integration** | 882 | User within a team |
| | 834 | Links of Friend (friend link among users) |
| | 316 | Private messages among users |
| | 1195 | Votes received by all teams |
| **Idea Space** each team can have a common exchange page | 110 | Ideas data sheets used |
| | 110 | Concepts description of idea |
| | 40 | Files (39 images + 1 PDF file) appended to the sheet |
| **Following Idea Space** | 118 | Participants received an idea evaluation |
| | 0 | Edition by others |
| | 135 | Team space used |
| **Following the team space** | 3 | Teams used an eRoom (webconference space) |
| | 34 | Private messages from manufacturers to participants by challenge |
| | 47 | Private messages in each team |
| | 47993 | Messages from Administrator |
| | 185 | Public message in public space by team |
| | 154 | Teams posted a YouTube video showing their results |

### 7.2.1 Use case 1: Participant Registration

In Figure 7.1, we observe the user's registration interface. 2403 user were registered, with two profiles assigned by the Webmaster: participant and industrial. 42 participants acting as industrials, they have access to all the team spaces that worked in the subject proposed. In total, 154 teams posted a video to participate in the contest; 19 teams did not use InnoKiz (they send their result by mail).


Figure 7.1 Screen shot Participant Registration

### 7.2.2 Use case 2: Team Integration

Each team shares a common private space as show in Figure 7.2. Inside Innokiz, there were three forms to be integrated to a team: Selecting a common subject, by the link friendship, and being aggregating directly to the team. 834 friendship links (known participants) were produced, more than 316 private messages were sent among users. Moreover, 1195 participants voted for the result (video) of another team. 135 teams generated their Team space, where they could share ideas and information.


Figure 7.2 Screen shot of Team Space

### 7.2.3 Use case 3: Idea space

One particular original feature of InnoKiz is the Idea space; it corresponds to the “IdeaBox”. We use this page as an indicator of acceptance of this use case by the teams. We see that 154 teams posted their results, 135 registered users used the functionality and some of these teams use the IdeaBox. In the IdeaBox section, teams could post and share their ideas in the form of an information sheet (as shown in Figure 7.3).

In the IdeaBox teams published their ideas, 110 idea sheets were presented as shown in Table 7.3. This functionality was used by 29 (21%) out of the 135 participating teams. Six virtual teams (17%) and 23 localized (83%). Teams were free to name or describe their ideas. There was more fluidity in the number of ideas by localized teams (mean of 3.96) and less for virtual teams (mean of 3.17).

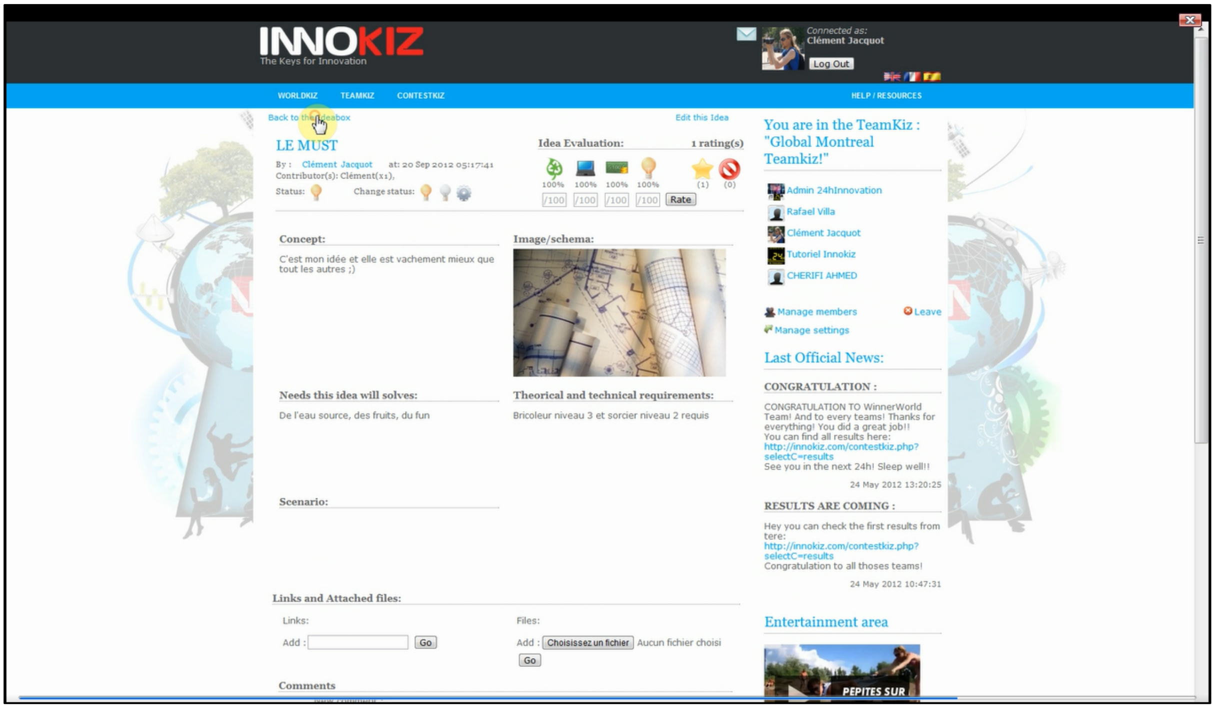



Figure 7.3 Screen shot of Idea Space

Table 7.3 Use of Ideabox for co-localized and remote teams

| | **Total n teams = 135** | **n teams Idea Box use** | **% Use** | **Discipline** |
|---|---|---|---|---|
| Co-localized team (localized in a site) | 123 | 23 | 19% | Computer science (n=8), Informatics, Mechanical and Industrial (n=4) Design, Industrial Engineering (n=4) |
| Remote teams (Virtual conditions) | 12 | 4 | 30% | Engineering (2), Design, Agriculture science (n=1), Food Engineering (n=1) |

In Figure 7.4, we can see the global utilization of Idea Space. 110 idea files were created. The name and the concept description were used, but the use of other descriptors, such as needs, technical and knowledge requirements, scenario description and graphical description (image) were less used. Semantically, the ideas definition was defined in two categories:

1) Description of parts of product to design, for example, screen, gloves, monitor, etc., or 2) Knowledge fields of product to design, for example, energy, eco-efficiency, transport system, etc.

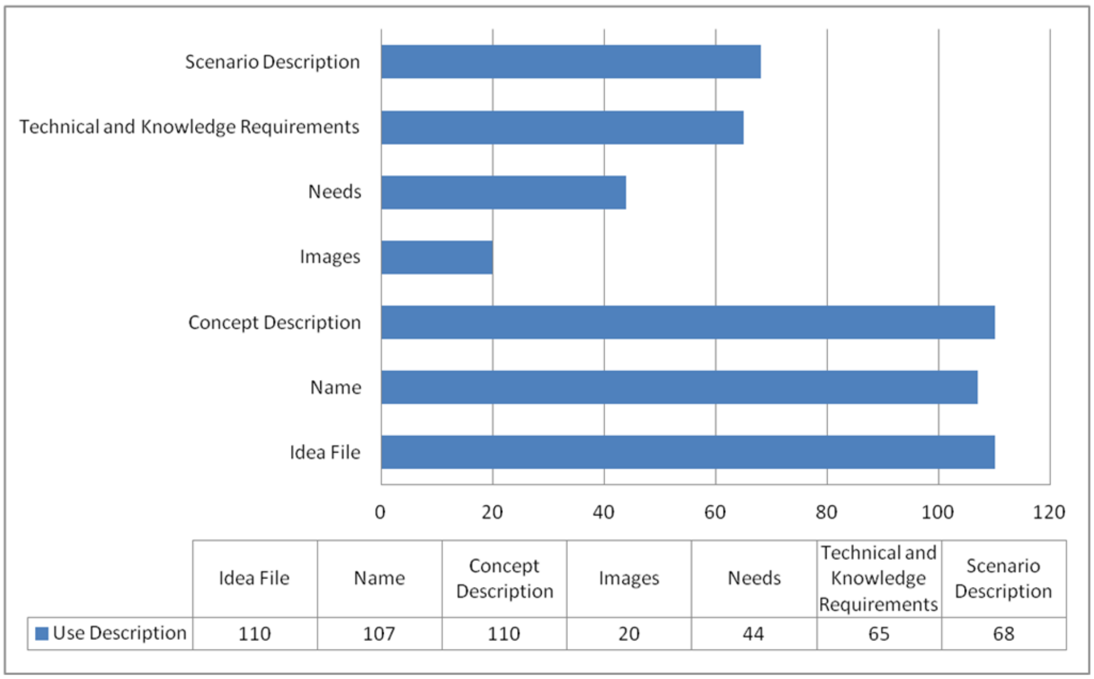



Figure 7.4 General Use description of Collaborative Tagging of Ideas in IdeaBox

The use of Platform among co-localized teams would seem to be influenced by the discipline of their participants: 50% (n=9) were computer science students, while the others were mechanical and industrial designers. In the case of remote teams, the sample was not big enough to demonstrate that it was a reason for using Innokiz; however, in the qualitative evaluation, these teams found InnoKiz useful for sharing ideas in the early design stage (see Section 8.3).

### 7.2.4 Use case 4: Following ideas

This use case was evaluated by the possibility to evaluate or to edit an idea of a teammate. During the project time, 118 participants evaluated an idea posted by a teammate, and the system automatically summarized and presented an average of the results of all notations introduced by a teammate, as shown in Figure 7.5. Following ideas was used in 119 times, when the teammates rated another idea. The edition of an idea of a teammate was not use.


Figure 7.5 Screenshot of statistics in IdeaBox

### 7.2.5 Use case 5: Following the team space

The page about the team information was generated automatically by Innokiz. 135 teams received 234 messages from the community, in the comments' frame as shown in Figure 7.6. In Table 7.4, we see some descriptive statistics about the message use and exchanges among teams, sponsors and the public. Some participants involved with the competition used the Platform to coach, encourage, explain, comment or answer questions in the team. These comments were written to the team in the public space comments tab.


Figure 7.6 Use case following Team Space

In Table 7.4 and Figure 7.7, we see the distribution of public comments to the 24H teams; the main topics are subject explanation (25%), when sponsors or coaches gave more information about their problem. Also, 24% of the comments were about creativity cues, some participants from the organization board messages or from sponsors interested in providing some clues to the teams.

Table 7.4 Public messages to the teams

| **Number** | **Categories** | **%** | **Description** | **n=messages** |
|---|---|---|---|---|
| 1 | Encouraging teams | 15 | Notes about team achievement | 5 |
| 2 | Subject explication | 25 | Questions about challenge | 8 |
| 3 | Organization greeting | 15 | Messages from organization board | 5 |
| 4 | Creativity cues | 24 | Give to teams | 8 |
| 5 | Sponsor contact | 21 | Sponsor message in public | 7 |
| | Total | 100% | Total | 33 |

The WebMaster used intensively the "following team space". He follows /alerts/gives information to the teams sending collective messages. Figure 7.8 presents the pattern of communication among teams and Webmaster. Table 7.5 presents the kind of messages exchanged.

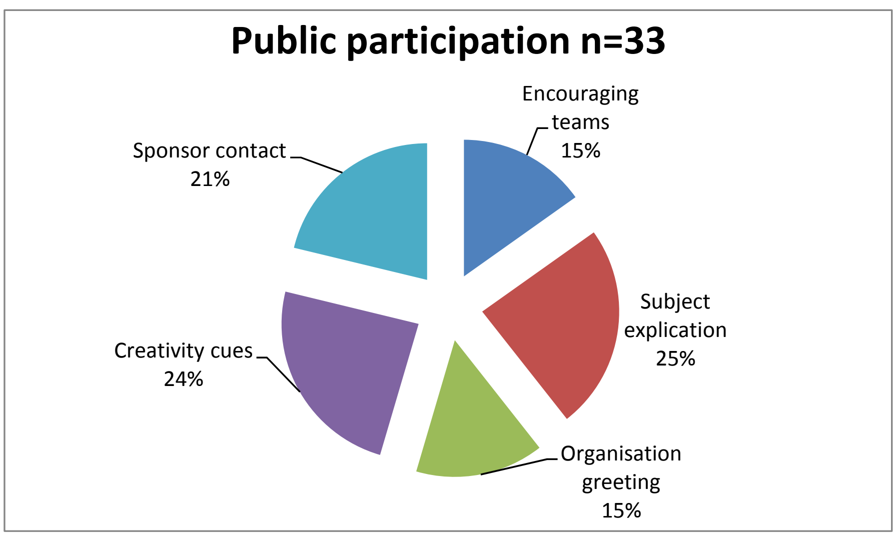



Figure 7.7 Messages by public to teams

In Table 7.5, we observe the distribution of messages: 27% were instructions, 20% timing and 23% news and results, meaning that 70% of the messages were related to the on-going support social process. 3% were invitations to form a space and 3% the resolution of bugs, while 3% represented research invitations. For information on the competition, we had 14%

covering votes and jury aspects and 5%, congratulations, and thus almost 19% relating to information about the competition.

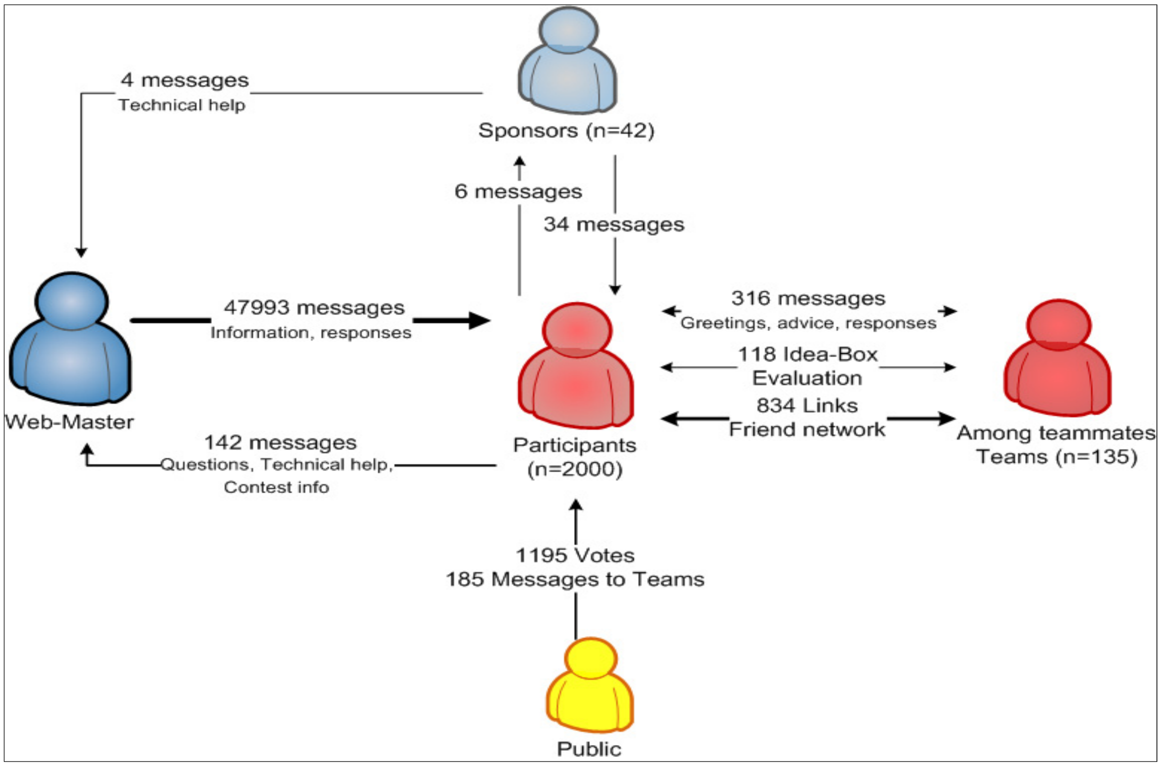



Figure 7.8 Messages exchanged and interaction among users of Platform

Table 7.5 Messages sent during the collaboration period

| Number | Categories | % | Description | n=messages |
|---|---|---|---|---|
| 1 | Training | 3 | Training and tutorial space | 1347 |
| 2 | Instructions | 27 | Welcome Innokiz | 4163 |
| 3 | | | WebTV invitation | 3650 |
| 4 | | | Challengekiz available | 1486 |
| 5 | | | Instructions of use | 1998 |
| 6 | | | Invitation twitter @24hinno | 1601 |
| 7 | Research invitation | 3 | Research invitation | 1504 |
| 8 | Support | 3 | Bugs/support | 1353 |
| 9 | Timing | 20 | Timing 3h | 1487 |
| 10 | | | Timing 9h | 1886 |
| 11 | | | Timing 15h | 4145 |
| 12 | | | Timing 21 h (3h left) | 2129 |
| 13 | Results and news | 23 | First video published | 2055 |
| 14 | | | Results UTT | 2226 |
| 15 | | | Results UNS | 2354 |
| 16 | | | First results ÉTS | 2224 |
| 17 | | | Result public vote | 2355 |
| 18 | Votes system | 14 | Votes system (top rated) | 2006 |
| 19 | | | Ranking Jury | 2221 |
| 20 | | | Winner votes | 2355 |
| 21 | Congratulation | 5 | Congratulation winner | 2254 |
| 22 | Others | 2 | Others personal responses | 991 |
| | Total | 100% | Total | 47790 |

### 7.2.6 Results of use cases evaluation

The results use cases are presented in Table 7.6; we identified two behaviors by remote and co-localized teams.

We obtained the following results:

1) ***Registration and Team Integration:*** During the competition, 91% of co-localized teams used the platform to get information about the competition and working on a co-localized basis, and only 9% worked entirely on the platform. These use cases were actively used by all participants (except by 17 teams –produced by technical conditions – China or not available Internet service)

Table 7.6 Descriptive statistics of platform use by remote and co-localized teams

| | All | Co-localized Teams | % | Remote mote-te-Teams | % | Proportion Co-localized | Proportion - Remote | Ratio - Co-localized | Ratio - Re-mote |
|---|---|---|---|---|---|---|---|---|---|
| **1)Registration and 2) Team integration Participant** | 820 | 750 | 91 | 70 | 9 | | | | |
| **3) Idea Space: Ideas in Idea-Box** | 110 | 93 | 85 | 17 | 15 | 8.87 | 4.53 | 1:9 | 1:5 |
| **4) Following idea space: Evaluation** | 115 | 96 | 83 | 19 | 17 | 8.98 | 4.24 | 1:9 | 1:4 |
| **4) Following idea space: Edition ideas of others** | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0:0 | 0:0 |
| **5) Following Team Space: Internal Messages** | 47 | 40 | 85 | 7 | 15 | 8.81 | 4.70 | 1:9 | 1:5 |
| **5) Following Team Space: Community Messages** | 249 | 223 | 90 | 26 | 10 | 8.37 | 6.70 | 1:9 | 1:7 |
| **5) Following Team Space: Public participation** | 34 | 34 | 100 | 0 | 0 | 7.50 | 0.00 | 1:7 | 1:0 |
| **5) Following Team Space: Polling (give a vote )** | 53 | 46 | 87 | 7 | 13 | 8.64 | 5.30 | 1:9 | 1:5 |
| **5) Following Team Space: Publishing results** | 154 teams participated – 135 publishing results in Innokiz | | | | | | | | |

2) ***Use of Idea space:*** We see that the remote teams were twice as likely as co-localized teams to publish ideas in the IdeaBox.
3) ***Following idea space:*** the use the evaluation tool was scarce and the edition tool was not used. However, the other tools as writing messages among teammates and giving an evaluation, was used in ratio of 1:9 by co-localized teams and in a ratio of 1:4 by remote teams.
4) ***Following Team space:*** Remote teams do not have public votes, and so their social external interaction was limited and low. We observed that this interaction could be easier for the co-localized team. These teams have enough social support, while remote teams do not. The social contact and the ongoing support produce an effect that is visualized in the platform.

About the user – acceptance testing, we have three assumptions related with:

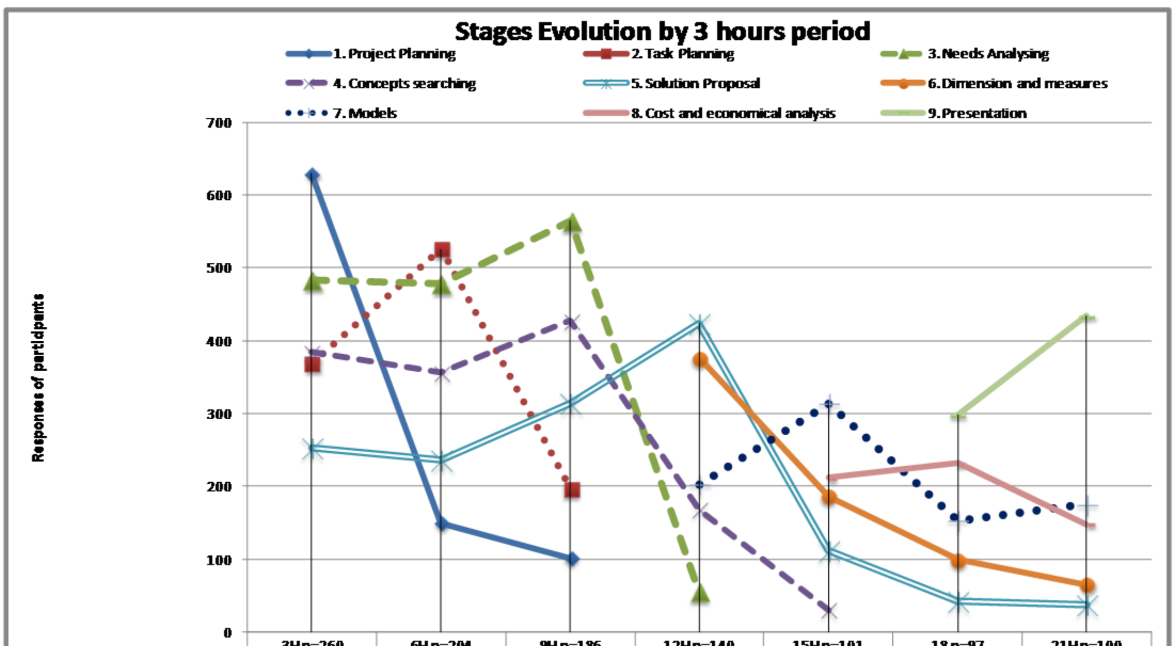
1) The use cases: registration, team integration, and following team space are use cases validated because facilitating the task of being part of competition and also, improving the awareness of the competition.
2) The use of idea space and following idea was low used because it was not useful (teams had not time to codify their ideas) or the use of idea space was not fostered by the competition. Particularly, for the time constraints of 24H of innovation.
3) The most new use case: generating an idea in the idea space and evaluating an idea of following Idea space, were low used. However, for the purpose of this first test, it can be enough that users take into account this functionality. This indicates that ideas codification could be useful for enhancing creative collaboration.

## 7.3 Task Analysis: Variability of tasks and functionalities used in the Platform

The first step to analyze creative performance consists in identify the task realized on the platform. Every 3 hours, we ask 267 participants to complete a brief online form covering the stage, the task and the tools used to realize it. In the following sections, we describe the stages and the tasks performed by creative teams of 24H. To standardize our study with a previous 24H research work, we used the stages classification proposed by Legardeur et al. (2010) and the ESTIA team. The results are summarized in the following subsections.

### 7.3.1 Stages and tasks accomplished by participants

Legardeur et al. (2010) define nine stages to develop a new concept in 24H: "1) Project planning, 2) Task planning, 3) Needs analysis, 4) Concepts searching, 5) Solutions proposal, 6) Dimensions and Measures, 7) Prototype, 8) Cost and economic analysis, 9) Presentation preparation". Each stage is differentiated by the kind of information and knowledge objects to be exchanged (Legardeur, Boujut and Tiger, 2010). In Figure 7.9 we traced the evolution of these stages using the prototype according to the participants responses.




| | 3Hn=260 | 6H n=204 | 9H n=186 | 12Hn=140 | 15Hn=101 | 18 n=97 | 21Hn=100 |
|---|---|---|---|---|---|---|---|
| 1. Project Planning | 629 | 150 | 102 | | | | |
| 2. Task Planning | 369 | 526 | 196 | | | | |
| 3. Needs Analysing | 483 | 478 | 565 | 55 | | | |
| 4. Concepts searching | 384 | 356 | 427 | 168 | 30 | | |
| 5. Solution Proposal | 253 | 237 | 314 | 424 | 112 | 42 | 38 |
| 6. Dimension and measures | | | | 376 | 186 | 99 | 65 |
| 7. Models | | | | 203 | 314 | 153 | 175 |
| 8. Cost and economical analysis | | | | | 212 | 232 | 148 |
| 9. Presentation | | | | | | 298 | 434 |

3H Period

Figure 7.9 Stages Evolution by time (each 3 hours)

In Figure 7.9, we see that in creative collaboration, the longest stage is the *Concept Searching* stage, which is quite extensive, and more sub-stages like *measuring/dimensioning, cost and economic analysis* and *testing or initial prototypes*. Also, we see that *Preparation for the presentation* is an isolated activity, which demands a lot of resources because this stage is imposed by the event organization (the goal is to win the competition). Other stages, such as *Project and Task Planning* and *Needs Analysis* are intensive in the first 9 hours. *Concept searching* is an active stage for the first 15 hours. During each stage, a participant can accomplish different tasks. Among these tasks, we have chosen nine grouped in four topics of collaborative teamwork (exchange of knowledge objects in design, as seen in Section 1.2):

a) Idea sharing,

b) Idea evaluation,

c) Team management, and

d) Knowledge management concerning client briefing or challenge demand.

Table 7.7 Task realized and definition of activities

| Tasks | Affirmations to define the task | Knowledge Object |
|---|---|---|
| **Ideas sharing** | **a)** I propose solution ideas | Ideas proposal: possible ideas that could solve the problem |
| | **b)** I chose or reject solutions | Problem definition: abstracting information that could solve the problem |
| **Ideas evaluation** | **c)** I define (part of) the method for evaluation | Interactive evaluation: each new element added is assessed to accomplish with criteria |
| | **d)** I engage the team in developing or stopping the development of a solution | |
| **Team management** | **e)** I define the planning | Idea elaboration: representation of ideas with details to be realized in a real situation |
| | **f)** I manage the tasks of team members | |
| | **g)** I act or react in order to converge in time. | |
| **Knowledge acquisition** | **h)** I refine or interpret the client brief | Sharing information inputs: needs, expectations, dreams, and insights.<br>Defining requirements: criteria definition based on initial inputs |
| | **i)** I interpret rules and restrictions | |

Table 7.7 presents the affirmation that describe the action realized, which means the task definition expressed in an active manner, for example, a) I propose solution ideas. In this affirmation, the participants identify their actions with the task realized during the last three hours.

In Figure 7.10, we see the summary of responses (in percentages %) for all participants. We use percentages to present the data information, because the number of participants willing to respond to the questions decreased, which could be because of demand, as we asked respondents to complete the form only if they actually worked during the period, and also, because of time constraints during the competition. We therefore obtained the percentage by distributing the responses for the number of participants in each time period.

Figure 7.10 summarized the results of how participant executed each task by stage; we observe some variations between the tasks performed at each stage. In the *Project Planning* stage*,* tasks such as *Idea sharing*, *Team management* and *Client briefing analysis* are more important than the *Idea Evaluation* task. These results also showed that each participant has a preference for one or other tasks. Each stage has the same kind of tasks. We found that the *Idea Sharing, Idea Evaluation, Team Management,* and *Knowledge Management* are as cycle of tasks presented at each stage. However, the distribution and the importance of one task depend on the goal of each stage. Thus, in Stage three, which deals with *Needs Analysis* or Stage eight, which covers *Cost and Economical Analysis*, we can see how the preferred task is the *Knowledge Management of client's briefing*. For Stage 5, *Solution Proposal*, the main task is Idea sharing, with Knowledge Management of client's briefing. The task *Idea Evaluation* is more frequent applied for Stage 3 or the *Needs Analyzing* and for Stage 5. However, *Idea Evaluation* is the least common task.

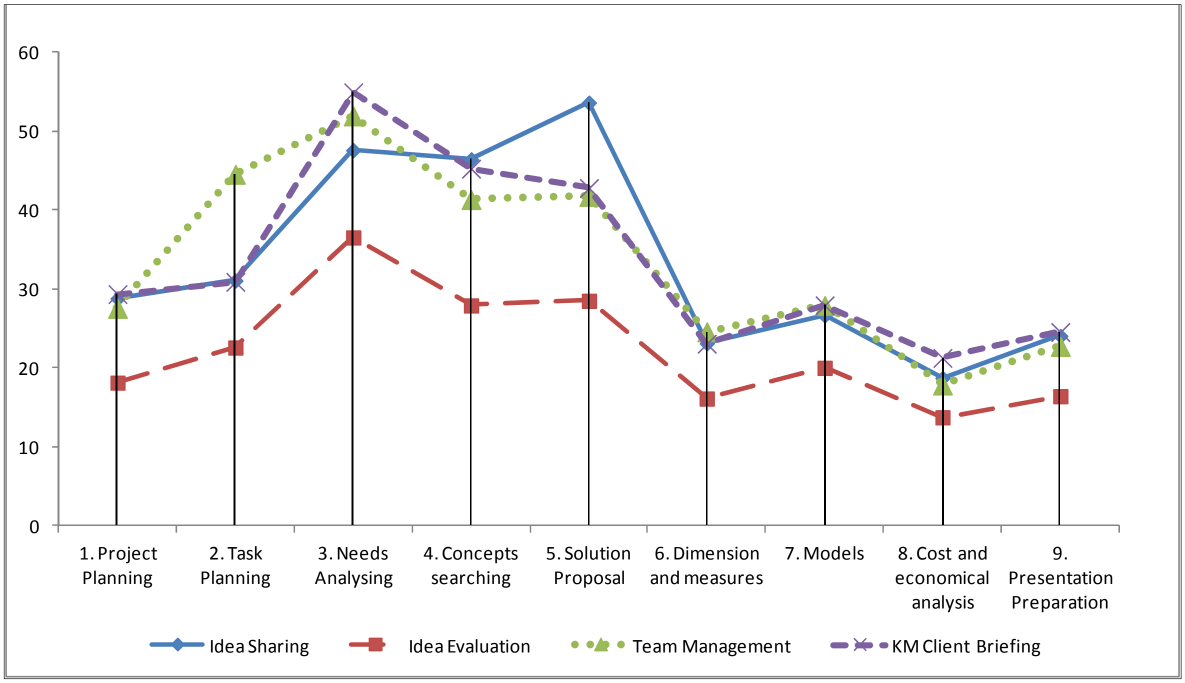
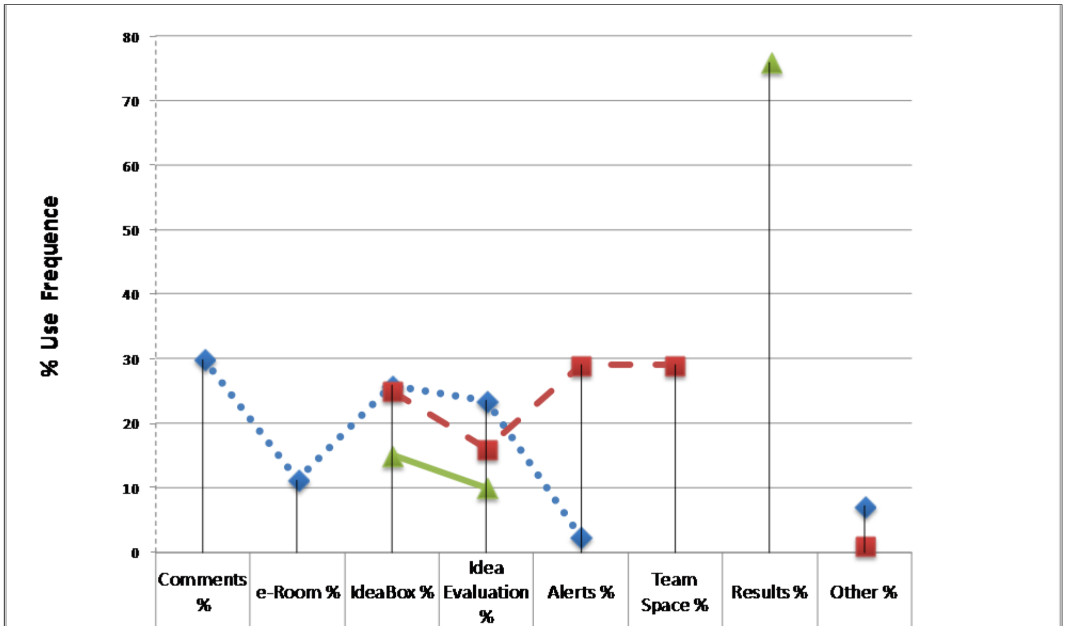



Figure 7.10 Summary in % of the main task realized during stages

#### 7.3.1.1 ICT Tools and media used in InnoKiz

In the online forms sent to participants, we interviewed them about the InnoKiz functionalities actually used during the first 6-hour period, and thereafter, for the between of 6 to 15 hours and from 15 to 21 hours. In Figure 7.11, we observed a variation in the use of each functionally within the platform. In the first 6 hours, the collaborative process was centered on comments exchanges (30%) and on information sharing in the eRoom (11%). Also, IdeaBox and Idea Evaluation usage came up to 26% and 23%, respectively, by participants during the first 6 hours, while the use of IdeaBox was stable at 25% from 15 hours, and dropped to 15% at 21 hours. The team space and alerts were used between 6 and 15 hours. At the end of the competition, teams focused on posting their results, and this functionality had a 76% usage. We see how the use of these functionalities is in direct proportion to the kind of task and stage of design of the team, as seen in the preceding section.

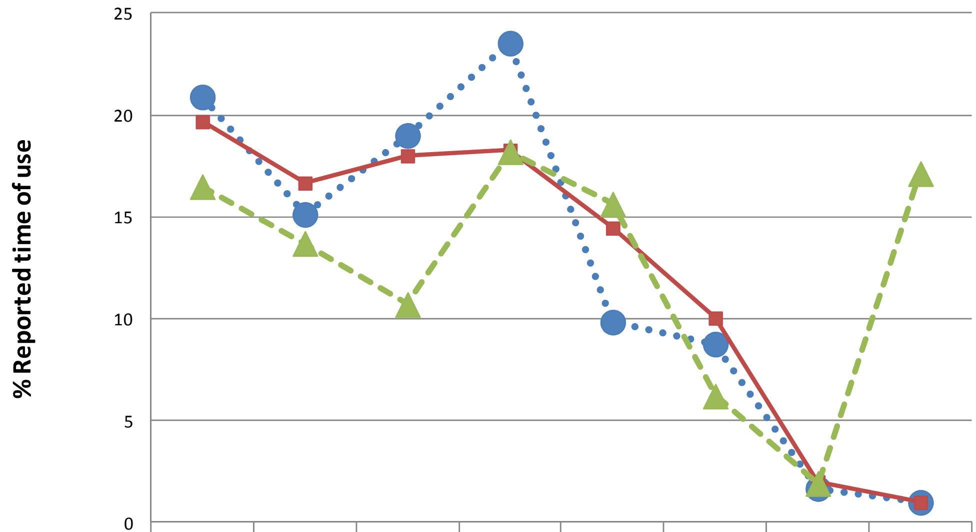



| | Comments % | e-Room % | IdeaBox % | Idea Evaluation % | Alerts % | Team Space % | Results % | Other % |
|---|---|---|---|---|---|---|---|---|
| 0H - 6H | 30 | 11 | 26 | 23 | 2 | | | 7 |
| 7H - 15H | | | 25 | 16 | 29 | 29 | | 1 |
| 16 - 21H | | | 15 | 10 | | | 76 | |

Figure 7.11 InnoKiz functionalities used at 6H, 15H and 21H

#### 7.3.1.2 Media and tools used during 21 hours of Project Development

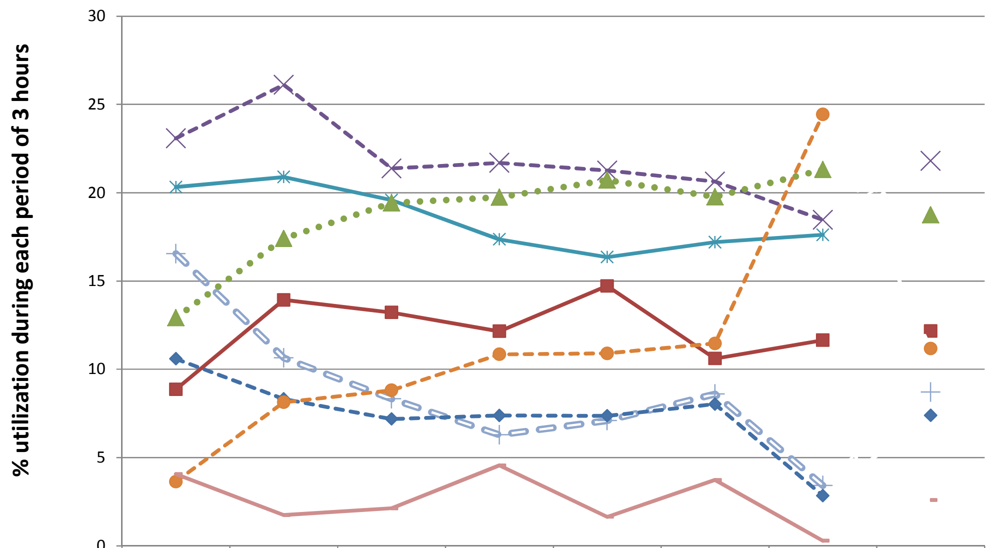
Figure 7.12 illustrates the number of times each participant worked using a media and tools. During the period from 0 hours to 6 hours, it was more intensively used as follows: Internet, 24%; Paper, 21%; Computers and Software, 19%, and Boards, 15%. In the second period (from 7 to 15 hours), usage continued as follows: Paper, 20%; Computers, 18%; Internet, 18%, and Boards, 17%. For the last period (between 16 and 21 hours), the use of the Internet, 18%; Video, 17%, and Paper, 16% are constant during all periods of project development. We observed that InnoKiz is used relatively constantly during the entire competition: 10%, 14%, and 16%. The use of InnoKiz is a little more intensive at the end of the competition in terms of the requirement to publish results. Regarding the use of mobile technology, participants used cell phones at 9%, 10% and 6%, while tablets and Ipads are scarcely used, coming in at only 2%.




| | Paper % | Board % | Computer & software % | Internet % | Innokiz % | Cellphone % | Ipad/PC Tablet % | Video % |
|---|---|---|---|---|---|---|---|---|
| 0H - 6H | 21 | 15 | 19 | 24 | 10 | 9 | 2 | 1 |
| 7H - 15H | 20 | 17 | 18 | 18 | 14 | 10 | 2 | 1 |
| 16H -21H | 16 | 14 | 11 | 18 | 16 | 6 | 2 | 17 |

Figure 7.12 Number of times reported for using media during 21 hours (%)

Figure 7.13 presents the most detailed description of the activities realized using ICT Tools. For a period of 3 hours, we tracked the use of Internet Search as a main activity realized by teams, and for the first hour, it was 24% and then it dropped to 18%. This data has been confirmed in the analysis of the use of ICT Tools in other studies (see Section 4.2.3). Secondly, in media use, we find the Paper (21%) and Computer and Software (19%). The browsing activity *"Internet searching"* is present in all the 21 hours, as well as the use of graphical software for image processing and video processing. Consulting InnoKiz as a source of information/guideline is more intensive in the first 6 hours, and decreases during the competition, both with respect to the use of videoconferencing and eRooms. Graphical software, such as AutoCAD, Catia, or SolidWorks are more frequently used, at 18 hours. Mind-mapping is a support activity that remains constant during the entire 21 hours.




| | 3H n=267 | 6H n=210 | 9H n=195 | 12H n= 148 | 15H n=115 | 18 H n=114 | 21H n=107 | Mean |
|---|---|---|---|---|---|---|---|---|
| Search Internet | 23 | 26 | 21 | 22 | 21 | 21 | 18 | 22 |
| Photos, images or videos | 20 | 21 | 20 | 17 | 16 | 17 | 18 | 18 |
| Drawing - Paint | 13 | 17 | 19 | 20 | 21 | 20 | 21 | 19 |
| InnoKiz - methods/guiding | 17 | 11 | 8 | 6 | 7 | 9 | 3 | 9 |
| Skype - Conference Web | 11 | 8 | 7 | 7 | 7 | 8 | 3 | 7 |
| Mind mapping | 9 | 14 | 13 | 12 | 15 | 11 | 12 | 12 |
| CAO - CAD | 4 | 8 | 9 | 11 | 11 | 11 | 24 | 11 |
| Other | 4 | 2 | 2 | 5 | 2 | 4 | 0 | 3 |

Figure 7.13 ICT Tools used for 3-hour period (answers in %)

### 7.3.2 Results of Task Analysis and the use of Prototype

In task analysis, we observed that:

- The creative task defined by the exchange of knowledge object is repeated as a cycle in each stage (Figure 7.10). This cycle of tasks, idea production, idea evaluation, team management and client briefing (knowledge management acquisition), is repeated by stage of design. As proposed theoretically in Section 5.3.
- Teams used the platform according with the organization demands: the most used functionality was the creation and the publishing of the results in the team space. This utilization varies in the period of time and stage accomplished (Figure 7.11)
- The platform has to cohabit with others Media as Internet and tools as paper, board or software (Figure 7.12 and 7.13).

## 7.4 Summary

In this chapter, we compared use cases modelled for the collaborative platform (presented in UML 2, in Chapter 5) and the current tasks realized by users in the prototype. These main tasks were: *Ideas sharing* performed in all stages, *Team Management* realized at the beginning of the work, *Knowledge Acquisition* realized in continuum, and with the *Idea Evaluation* task being the least used.

Regarding the use of InnoKiz functionalities, during the first six hours, the Comments bar, e-Room (videoconferencing such as Vyew™), IdeaBox (Ideas presented in a Board), Idea Evaluation and Alerts were used. From seven hours to 15 hours, the IdeaBox, the idea Evaluation, the Alerts and the team space were most used, and at the end of 24H, the result posting functionality (in the team space) took the lead in terms of usage. This utilization validates the use cases proposed theoretically in Chapter 5.

We observed the use in parallel of the platform with other ICT tools, especially the *Internet Search* activity as a main interaction reported. Remote teams (19%) and co-localized teams (30%) used the prototype differently. The remote teams used the new functionality "Collaborative tagging" to display and evaluate ideas. While co-localized teams receive comments and contribution of external partners (free association) and public comments, votes and contributions. This result supports the fact that previous personal interaction is very important for stimulating creative contributions and also, the collaborative platform is also useful for co-localized teams. We conclude that there was an interaction inside the platform for remote and co-localized teams, particularly when the information, ideas and knowledge are needed to accomplished the overall task of 24H, which is –posting the results into the platform and voting for a project of other team.

In the next chapter, we will analyze the performance and perceived usability by the platform's users.

# CHAPTER 8

# ANALYSIS OF THE CREATIVE COLLABORATION PERFORMANCE ON AN ICT PLATFORM

In this chapter, we present the results obtained by applying the Performance Analysis (PAN) and the usability test on the collaborative platform (prototype). The results indicate that the perceived "creative collaboration performance" of participants is satisfactory; 24H teams found Innokiz useful for collaborating during the ideation stage. As seen in Chapter 7, the use of a collaborative platform is related to the task executed during the development of the project. We observed the satisfaction in the use of the platform is interrelated with previous ICT experience (number of groupware) and previous experience in project development.

In this chapter, we also propose a creative collaboration performance index composed of creative individual assessment (according to VanGundy (1984)), creative team performance during the use of the platform, and previous experience using ICT Tools (groupware) in project development. At the end of this chapter, we present new functionalities that should be aggregated to improve creative collaboration in an ICT platform.

## 8.1 Testing Collaborative Platform through Performance Analysis (PAN)

As mentioned in the Methodology (Section 3.6.4), to validate the data collected on the user performance in the prototype, we will apply Performance Analysis (PAN). PAN determines how users complete their tasks on the platform in terms of "result quality, time, and total amount of work done" (Antunes et al., 2008, p. 8:3). As seen in Chapter 7, creative teams must accomplish tasks of different natures and having different goals; moreover, most parts of the knowledge exchanged is tacit. For these reasons, measuring performance in a collaborative task is quite complex. In a PAN assessment, the researcher has to "define a way to compute the quality (e.g., group recall in a collaborative retrieval task), and maximize the quality vs. work done, either analytically or experimentally" (idem). In our study, creative performance involves the individual idea production and their possibility to express or share conveniently a creative contribution (creative performance is explained in the Section 8.2). In contrast to performance, usability "is closely related to ease of learning or learnability without necessarily implying a high performance in task execution" Seffah et al. (2006, p. 168). For collaborative interfaces, Germani, Mengoni and Peruzzini (2012b) propose an integrated usability and performance index for the analysis of co-creative activities (co-design). In this index, there are three factors to be analyzed: the task, the team, and the cognitive performances of each member.

In our research, we propose an approach that combines the perceived creative performance by users and the results obtained by interaction during the use of their Platform. This approach consists of creative individual assessment according to VanGundy's, creative performance perceived during the use of the platform, and previous experience using ICT Tools (groupware) during project development (this variable is measured asking for the quantity of used groupware). In the next section, we present the data collected to analyze the creative collaboration performance.

## 8.2 Creative Collaboration Performance on the Platform

At the beginning of the 24H research (Appendix I), we handed a first biographic form asking about previous experience in working on collaborative projects and the use of groupware, and a Van Gundy's test about individual creative assessment (VanGundy, 1984). At the end of the 24H, after the continuous use of InnoKiz, we applied VanGundy's creative team assessment. This assessment measures the following variables related to teams' internal characteristics: 1) homogeneity in genre, 2) diversity of personality, 3) homogeneity in creative skills, 4) compatibility, when mutual needs are fulfilled, 5) ability to work together, 6) time for team building (should be at least two years; less than two years of work experience would have a lower score), and 7) group size (should be comprised of 3 to 4 members) (ibid). It was also developed a Likert-type test to assess the individual perception on the use of the prototype, according to a scale of 1 to 5 (strongly disagree to strongly agree rating scale). This Likert-type test was adapted from VanGundy (1984), as shown in Figure 8.1. The Likert scale test is a psychometric scale, with which a researcher can capture the variation in the intensity of the user's perception towards a phenomenon. In our study, we measure the user's perception towards their performance using the platform to share their ideas with their team. For the performance analysis, we use the Likert-scale test as descriptive statistics summarizing the results on an ordinal basis, and we do not use it for a non-parametric test used in statistical inferences.

The following questions collect data about how the InnoKiz platform enables you to do your work and share your ideas.

Rating scale:
5 - Strongly agree
4 - Agree
3 - Neither agree nor disagree
2 - Disagree
1 - Strongly disagree

| | **Questions** | **Score** | | | | |
|---|---|---|---|---|---|---|
| | Using InnoKiz … | | | | | |
| | | **5** | **4** | **3** | **2** | **1** |
| Q1 | I easily express my ideas | 5 | 4 | 3 | 2 | 1 |
| Q2 | All my ideas were well expressed | 5 | 4 | 3 | 2 | 1 |
| Q3 | I know the advances in my project | 5 | 4 | 3 | 2 | 1 |
| Q4 | I understand and judge the ideas of my teammates | 5 | 4 | 3 | 2 | 1 |
| Q5 | I observe the changes made by my teammates | 5 | 4 | 3 | 2 | 1 |
| Q6 | I would like to use this groupware in my next project | 5 | 4 | 3 | 2 | 1 |
| Q7 | It is easy to use this groupware | 5 | 4 | 3 | 2 | 1 |
| Q8 | All the functions, windows and menus are useful | 5 | 4 | 3 | 2 | 1 |
| Q9 | I visualize the recent activities of my teammates | 5 | 4 | 3 | 2 | 1 |
| Q10 | Groupware is not useful in the briefing of the project (preliminary stage) (* inverse score) | 5 | 4 | 3 | 2 | 1 |
| Q11 | Groupware is friendly | 5 | 4 | 3 | 2 | 1 |
| Q12 | Groupware lets me be more creative | 5 | 4 | 3 | 2 | 1 |
| Q13 | I could view responses and criticisms of my teammates | 5 | 4 | 3 | 2 | 1 |
| Q14 | I know the direction that the project is taking | 5 | 4 | 3 | 2 | 1 |
| Q15 | I could be connected with my social networking and other media (mobile telephone or skype) | 5 | 4 | 3 | 2 | 1 |
| Q16 | My team creativity was boosted (give advantage) with the use of this groupware | 5 | 4 | 3 | 2 | 1 |

Figure 8.1 Form used to assess the perception of the performance by participants

In Table 8.1, we present the data obtained by applying the questionnaire during the 5th (Test 1) and the 6th editions (Test 2) of 24H. With this data, we realized a reliability test Cronbach's-Alpha; which allows us to establish the internal consistency between the 16 questions proposed and variable performance.

Cronbach's Alpha $\propto$ is defined by the following formula:

$$\propto = \frac{\mathrm{K}}{K-1}\left(1-\frac{\sum_{i=1}^{K}\sigma_{Yi}^{2}}{\sigma_{x}^{2}}\right) \tag{8.1}$$

K = Number of components (items or questions)
$\sigma_{Yi}^{2}$ = Variance of components $i$ for current sample
$\sigma_{x}^{2}$ = Variance of observed total scores

The questionnaire was applied two separate times; for Test 1 (May, 2011), we obtained 0.9461,with n=28 and for the second Test 2 (May, 2012), 0.9608, with n=40. As can be seen at the corner right-bottom Table 8.1, results over 0.9 indicate excellent consistency between the questions formulated and their measure of the variable perceived performance using the collaborative platform.

Table 8.1 Data obtained in Likert scaleform

| TEST 1 RELIABILITY | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 | P16 | P17 | P18 | P19 | P20 | P21 | P22 | P23 | P24 | P25 | P26 | P27 | P28 | Variance Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q1 | 1 | 3 | 3 | 2 | 3 | 5 | 3 | 5 | 5 | 3 | 3 | 4 | 2 | 3 | 4 | 4 | 3 | 5 | 3 | 1 | 3 | 3 | 2 | 3 | 4 | 5 | 3 | 2 | 1.2857 |
| Q2 | 1 | 3 | 3 | 2 | 3 | 5 | 4 | 4 | 5 | 4 | 3 | 3 | 2 | 4 | 5 | 4 | 3 | 4 | 4 | 1 | 3 | 3 | 1 | 3 | 3 | 5 | 3 | 2 | 1.3598 |
| Q3 | 1 | 3 | 2 | 4 | 3 | 5 | 4 | 4 | 5 | 4 | 3 | 4 | 5 | 3 | 4 | 4 | 3 | 5 | 5 | 1 | 4 | 3 | 4 | 2 | 4 | 5 | 3 | 2 | 1.3690 |
| Q4 | 1 | 3 | 3 | 3 | 3 | 5 | 3 | 4 | 5 | 2 | 3 | 3 |  | 3 | 4 | 4 | 3 | 5 | 3 | 2 | 3 | 3 | 4 | 3 | 5 | 5 | 3 | 2 | 1.0769 |
| Q5 | 1 | 3 | 3 | 3 | 3 | 5 | 3 | 5 | 4 | 5 | 3 | 4 | 5 | 5 | 4 | 4 | 3 | 3 | 5 | 2 | 4 | 3 | 4 | 3 | 4 | 5 | 3 | 2 | 1.1362 |
| Q6 | 1 | 3 | 3 | 3 | 3 | 5 | 4 | 3 | 5 | 4 | 3 | 5 | 5 | 3 | 3 | 4 | 3 | 4 | 4 | 2 | 4 | 3 | 4 | 2 | 5 | 5 | 3 | 2 | 1.1481 |
| Q7 | 1 | 3 | 3 | 3 | 3 | 5 | 4 | 4 | 5 | 5 | 3 | 4 | 4 | 5 | 3 | 5 | 3 | 5 | 4 | 1 | 3 | 3 | 4 | 2 | 4 | 5 | 3 | 2 | 1.3690 |
| Q8 | 1 | 3 | 3 | 3 | 3 | 5 | 3 | 3 | 5 | 4 | 3 | 4 | 4 | 2 | 3 | 5 | 3 | 5 | 3 | 1 | 3 | 3 | 3 | 2 | 5 | 5 | 3 | 2 | 1.3228 |
| Q9 | 1 | 3 | 3 | 4 | 3 | 5 | 4 | 5 | 5 | 3 | 3 | 3 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 5 | 3 | 4 | 3 | 5 | 5 | 3 | 2 | 1.1746 |
| Q10 | 5 | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 1 | 3 | 4 | 0.8929 |
| Q11 | 1 | 3 | 3 | 4 | 3 | 5 | 4 | 3 | 4 | 1 | 3 | 4 | 3 | 4 | 3 | 5 | 3 | 4 | 4 | 2 | 4 | 3 | 3 | 4 | 3 | 5 | 3 | 2 | 1.0410 |
| Q12 | 1 | 3 | 3 | 2 | 3 | 5 | 4 | 4 | 4 | 3 | 3 | 3 | 1 | 3 | 3 | 5 | 3 | 3 | 3 | 1 | 4 | 3 | 3 | 3 | 5 | 5 | 3 | 2 | 1.2381 |
| Q13 | 1 | 3 | 3 | 4 | 3 | 5 | 4 | 4 | 4 | 4 | 3 | 3 | 5 | 3 | 4 | 4 | 3 | 3 | 4 | 2 | 4 | 3 | 4 | 3 | 5 | 5 | 3 | 2 | 0.9259 |
| Q14 | 1 | 3 | 3 | 3 | 3 | 5 | 5 | 3 | 5 | 3 | 3 | 4 | 5 | 3 | 3 | 4 | 3 | 4 | 2 | 2 | 4 | 3 | 4 | 3 | 5 | 5 | 3 | 2 | 1.1429 |
| Q15 | 1 | 3 | 3 | 4 | 3 | 5 | 5 | 3 | 5 | 3 | 3 | 3 | 1 | 5 | 4 | 4 | 3 | 3 | 2 | 1 | 4 | 3 | 4 | 2 | 5 | 5 | 3 | 2 | 1.5450 |
| Q16 | 1 | 3 | 3 | 3 | 3 | 5 | 5 | 3 | 5 | 4 | 3 | 2 | 1 | 3 | 3 | 4 | 3 | 3 | 4 | 1 | 3 | 3 | 3 | 2 | 3 | 5 | 3 | 2 | 1.2540 |
| Score | 20 | 48 | 47 | 49 | 48 | 76 | 62 | 59 | 72 | 55 | 48 | 56 | 51 | 55 | 57 | 66 | 48 | 63 | 58 | 26 | 58 | 48 | 54 | 44 | 69 | 76 | 48 | 34 | 170.6177 |
| % | 0.3 | 0.6 | 0.6 | 0.6 | 0.6 | 1.0 | 0.8 | 0.7 | 0.9 | 0.7 | 0.6 | 0.7 | 0.6 | 0.7 | 0.7 | 0.8 | 0.6 | 0.8 | 0.7 | 0.3 | 0.7 | 0.6 | 0.7 | 0.6 | 0.9 | 1.0 | 0.6 | 0.4 | 0.0267 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **Cronbach's Alpha** |  |  | 0.9461 |

Table 8.1 Continuation

| TEST 2 | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 | P16 | P17 | P18 | P19 | P20 | P21 | P22 | P23 | P24 | P25 | P26 | P27 | P28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Q1** | 2 | 1 | 4 | 3 | 3 | 5 | 4 | 4 | 4 | 5 | 4 | 3 | 3 | 3 | 1 | 3 | 3 | 5 | 1 | 3 | 3 | 3 | 1 | 1 | 5 | 5 | 2 | 1 |
| **Q2** | 4 | 1 | 4 | 3 | 4 | 5 | 4 | 5 | 4 | 4 | 4 | 3 | 4 | 4 | 1 | 3 | 4 | 5 | 1 | 3 | 3 | 2 | 1 | 1 | 5 | 5 | 2 | 1 |
| **Q3** | 3 | 3 | 5 | 3 | 5 | 5 | 5 | 5 | 4 | 5 | 3 | 3 | 4 | 4 | 1 | 3 | 5 | 5 | 1 | 3 | 3 | 4 | 1 | 1 | 4 | 5 | 2 | 2 |
| **Q4** | 3 | 1 | 5 | 3 | 5 | 5 | 5 | 4 | 4 | 5 | 4 | 3 | 4 | 4 | 1 | 4 | 4 | 5 | 1 | 3 | 3 | 3 | 1 | 1 | 5 | 5 | 2 | 2 |
| **Q5** | 3 | 1 | 5 | 3 | 5 | 5 | 5 | 5 | 4 | 5 | 4 | 3 | 1 | 4 | 1 | 4 | 4 | 5 | 1 | 3 | 3 | 3 | 1 | 1 | 5 | 5 | 2 | 2 |
| **Q6** | 4 | 4 | 5 | 3 | 3 | 5 | 3 | 5 | 4 | 4 | 4 | 3 | 1 | 3 | 1 | 1 | 5 | 5 | 1 | 3 | 2 | 3 | 1 | 1 | 5 | 5 | 2 | 2 |
| **Q7** | 3 | 4 | 3 | 3 | 5 | 5 | 4 | 4 | 3 | 3 | 4 | 3 | 2 | 3 | 1 | 1 | 3 | 5 | 1 | 3 | 3 | 4 | 1 | 1 | 5 | 5 | 2 | 1 |
| **Q8** | 3 | 4 | 2 | 3 | 3 | 5 | 3 | 4 | 2 | 3 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | 5 | 1 | 3 | 3 | 2 | 1 | 1 | 4 | 5 | 2 | 1 |
| **Q9** | 3 | 4 | 3 | 3 | 5 | 5 | 5 | 4 | 4 | 3 | 4 | 3 | 3 | 2 | 1 | 1 | 4 | 5 | 1 | 3 | 4 | 3 | 1 | 1 | 4 | 3 | 2 | 1 |
| **Q10** | 3 | 5 | 4 | 3 | 3 | 5 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 4 | 5 | 4 | 3 | 5 | 5 | 3 | 3 | 2 | 5 | 5 | 3 | 1 | 4 | 5 |
| **Q11** | 3 | 4 | 3 | 3 | 3 | 5 | 3 | 5 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 4 | 5 | 1 | 3 | 4 | 2 | 1 | 1 | 4 | 5 | 2 | 1 |
| **Q12** | 4 | 1 | 5 | 3 | 3 | 5 | 3 | 5 | 3 | 2 | 3 | 3 | 4 | 4 | 1 | 1 | 4 | 5 | 1 | 3 | 2 | 2 | 1 | 1 | 3 | 3 | 2 | 1 |
| **Q13** | 5 | 2 | 4 | 3 | 5 | 5 | 5 | 5 | 4 | 3 | 4 | 3 | 4 | 2 | 1 | 3 | 4 | 5 | 1 | 3 | 3 | 4 | 1 | 1 | 4 | 4 | 2 | 1 |
| **Q14** | 5 | 5 | 5 | 3 | 3 | 5 | 4 | 4 | 4 | 2 | 4 | 3 | 4 | 3 | 1 | 2 | 4 | 5 | 1 | 3 | 3 | 2 | 1 | 1 | 4 | 5 | 2 | 1 |
| **Q15** | 4 | 3 | 4 | 3 | 3 | 5 | 5 | 4 | 4 | 3 | 4 | 3 | 4 | 2 | 1 | 2 | 3 | 5 | 1 | 3 | 3 | 2 | 1 | 1 | 4 | 5 | 2 | 1 |
| **Q16** | 2 | 1 | 5 | 3 | 1 | 5 | 4 | 4 | 3 | 2 | 4 | 3 | 4 | 2 | 1 | 1 | 3 | 5 | 1 | 3 | 2 | 3 | 1 | 1 | 4 | 5 | 2 | 1 |
| **Score** | 54 | 44 | 66 | 48 | 59 | 80 | 65 | 69 | 56 | 54 | 59 | 48 | 48 | 50 | 20 | 35 | 60 | 80 | 20 | 48 | 47 | 44 | 20 | 20 | 68 | 71 | 34 | 24 |
| **%** | 0.7 | 0.6 | 0.8 | 0.6 | 0.7 | 1.0 | 0.8 | 0.9 | 0.7 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.3 | 0.4 | 0.8 | 1.0 | 0.3 | 0.6 | 0.6 | 0.6 | 0.3 | 0.3 | 0.9 | 0.9 | 0.4 | 0.3 |

| **TEST 2** (continuation) | **P29** | **P30** | **P31** | **P32** | **P33** | **P34** | **P35** | **P36** | **P37** | **P38** | **P39** | **P40** | **Variance** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 2 | 4 | 1 | 3 | 3 | 2 | 1 | 5 | 5 | 4 | 2 | 1.9462 |
| | 5 | 1 | 3 | 2 | 3 | 3 | 2 | 1 | 5 | 4 | 3 | 1 | 2.0199 |
| | 5 | 4 | 5 | 3 | 3 | 3 | 3 | 2 | 5 | 5 | 5 | 4 | 1.7333 |
| | 5 | 3 | 5 | 3 | 3 | 3 | 3 | 2 | 5 | 5 | 4 | 2 | 1.8436 |
| | 4 | 2 | 5 | 3 | 3 | 3 | 3 | 4 | 5 | 4 | 4 | 2 | 1.9327 |
| | 5 | 1 | 4 | 2 | 3 | 3 | 2 | 1 | 4 | 4 | 3 | 2 | 1.9974 |
| | 4 | 3 | 4 | 2 | 3 | 3 | 3 | 1 | 3 | 5 | 4 | 1 | 1.7173 |
| | 4 | 3 | 3 | 1 | 3 | 3 | 2 | 1 | 3 | 5 | 3 | 2 | 1.4974 |
| | 4 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 4 | 3 | 2 | 1.4609 |
| | 2 | 4 | 5 | 2 | 3 | 3 | 3 | 5 | 3 | 1 | 3 | 3 | 1.3686 |
| | 5 | 3 | 4 | 2 | 3 | 3 | 3 | 1 | 2 | 5 | 5 | 3 | 1.6923 |
| | 4 | 2 | 3 | 1 | 3 | 3 | 3 | 1 | 2 | 5 | 3 | 3 | 1.6660 |
| | 3 | 2 | 4 | 2 | 3 | 3 | 3 | 1 | 5 | 4 | 3 | 2 | 1.7205 |
| | 4 | 3 | 4 | 2 | 3 | 3 | 2 | 1 | 5 | 4 | 3 | 3 | 1.7205 |
| | 5 | 2 | 4 | 2 | 3 | 3 | 3 | 1 | 5 | 4 | 4 | 3 | 1.6308 |
| | 5 | 2 | 4 | 1 | 3 | 3 | 3 | 1 | 1 | 4 | 3 | 2 | 1.9077 |
| | 69 | 40 | 64 | 31 | 48 | 48 | 43 | 25 | 61 | 68 | 57 | 37 | 280.6641 |
| | 0.9 | 0.5 | 0.8 | 0.4 | 0.6 | 0.6 | 0.5 | 0.3 | 0.8 | 0.9 | 0.7 | 0.5 | |
| | | | | | | | | | **Cronbach's Alpha** | | | | **0.9608** |

| **Cronbach's alpha** | **Internal consistency** |
|---|---|
| $\alpha \geq 0.9$ | Excellent |
| $0.8 \leq \alpha < 0.9$ | Good |
| $0.7 \leq \alpha < 0.8$ | Acceptable |
| $0.6 \leq \alpha < 0.7$ | Questionable |
| $0.5 \leq \alpha < 0.6$ | Poor |
| $\alpha < 0.5$ | Unacceptable |

Table 8.2 describes how Likert-type test questions were formulated to determine the inter-connection between four evaluation categories related to creative collaboration: creative performance (Q1, Q4, Q12), team performance (Q3, Q5, Q9, Q14, Q16), usefulness (Q2, Q7, Q8, Q10, Q11), and accessibility (Q15). These categories are distributed in three dimensions

of analysis: if the Knowledge is tacit or explicit, if the Social Level is individual or collective, and finally, the Direction of inputs from Individual to Collective (In. to Co.) or vice versa (Co. to In.). Ideas, as tacit knowledge, are presented to the team and are then transformed into an explicit form.

Table 8.2 Form used to measure the perception of performance by participants

| # | Metrics | Questions | Knowledge exchange | | Social level | | Direction | |
|---|---|---|---|---|---|---|---|---|
| | | Using InnoKiz … | Tacit | Explicit | Individual | Collective | In. to Co. | Co. to In. |
| Q1 | Creativity performance | I easily express my ideas | X | | X | | X | |
| Q2 | Usefulness | All my ideas were well expressed | | X | X | | X | |
| Q3 | Team performance | I know the advances in my project | X | | X | | | X |
| Q4 | Individual Creativity Performance | I understand and judge the ideas of my teammates | | X | | X | | X |
| Q5 | Team performance | I observe the changes made by my teammates | X | | | X | | X |
| Q6 | Satisfaction | I would like to use this groupware in my next project | X | | X | | X | |
| Q7 | Usefulness | It is easy to use this groupware | X | | X | | N/A | |
| Q8 | Usefulness | All the functions, windows and menus are useful | N/A | | N/A | | | |
| Q9 | Performance | I visualize the recent activities of my teammates | X | | X | | | X |
| Q10 | Usefulness | Groupware is not useful in the briefing of the project (preliminary stage) (* inverse score) | N/A | | N/A | | N/A | |
| Q11 | Usefulness | Groupware is friendly | N/A | | N/A | | N/A | |
| Q12 | Creativity performance | Groupware lets me be more creative | X | | X | | X | |
| Q13 | Team performance | I could view responses and criticisms of my teammates | | X | | X | | X |
| Q14 | Team performance | I know the direction that the project takes | X | | X | | | X |
| Q15 | Accessibility | I could be connected with my social networking and other media (mobile telephone - Skype) | X | | | X | X | |
| Q16 | Team performance | My team creativity was boosted (give advantage) with the use of this groupware | X | | | X | | X |

Questions were grouped into separate categories. Table 8.3 shows a synthesis of the results obtained and summarizes the other results obtained regarding experience in the use of groupware, and the results of individual and teamwork assessment (Obtained in the biographical form –filling up in the first part of study by all participants).

Table 8.3 Condensed data of users' evaluation of Platform

| | InnoKiz Test - Perceived Performance | | | | | Creat - Assessment | | Groupware Experience | | | Likes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| n=40 | Creat-Perf (Q1,Q4, Q12) | Team-Perf (Q3,Q5,Q9, Q14,Q16) | Usefulness (Q2,Q7,Q8, Q10,Q11) | Accessibility (Q15) | Total Performance | Individual Test | Teamwork Test | Use Groupware | Experience | Total Experience | Teamwork |
| P1 | 3,00 | 3,2 | 3,2 | 4 | 3,35 | 3,5 | 3,56 | 3 | 11 | 14 | 5 |
| P2 | 1,00 | 2,8 | 3,6 | 3 | 2,60 | 4,2 | 4,33 | 1 | 1 | 2 | 5 |
| P3 | 4,67 | 4,6 | 3,2 | 4 | 4,12 | 2 | 3,78 | 3 | 5 | 8 | 5 |
| P4 | 3,00 | 3 | 3 | 3 | 3,00 | 3 | 3,00 | 4 | 0 | 4 | 5 |
| P5 | 3,67 | 3,8 | 3,6 | 3 | 3,52 | 3,8 | 3,67 | 5 | 11 | 16 | 5 |
| P6 | 5,00 | 5 | 5 | 5 | 5,00 | 4 | 3,67 | 3 | 5 | 8 | 5 |
| P7 | 4,00 | 4,6 | 3,4 | 5 | 4,25 | 4,45 | 3,89 | 5 | 5 | 10 | 5 |
| P8 | 4,33 | 4,4 | 4 | 4 | 4,18 | 4 | 4,22 | 4 | 5 | 9 | 5 |
| P9 | 3,67 | 3,8 | 2,8 | 4 | 3,57 | 3,4 | 3,00 | 3 | 5 | 8 | 5 |
| P10 | 4,00 | 3,4 | 3 | 3 | 3,35 | 4 | 3,00 | 5 | 11 | 16 | 5 |
| P11 | 3,67 | 3,8 | 3,4 | 4 | 3,72 | 3,5 | 3,67 | 2 | 5 | 7 | 5 |
| P12 | 3,00 | 3 | 3 | 3 | 3,00 | 3,1 | 3,33 | 2 | 5 | 7 | 5 |
| P13 | 3,67 | 3,2 | 2,4 | 4 | 3,32 | 3,4 | 3,11 | 4 | 5 | 9 | 5 |
| P14 | 3,67 | 3 | 3,4 | 2 | 3,02 | 3,95 | 3,89 | 2 | 5 | 7 | 5 |
| P15 | 1,00 | 1 | 1,8 | 1 | 1,20 | 3,5 | 3,89 | 2 | 5 | 7 | 5 |
| P16 | 2,67 | 2,2 | 2 | 2 | 2,22 | 3,15 | 3,67 | 4 | 5 | 9 | 5 |
| P17 | 3,67 | 4 | 3,4 | 3 | 3,52 | 3,75 | 3,89 | 4 | 5 | 9 | 5 |
| P18 | 5,00 | 5 | 5 | 5 | 5,00 | 3,35 | 5,00 | 3 | 1 | 4 | 5 |
| P19 | 1,00 | 1 | 1,8 | 1 | 1,20 | 3,15 | 4,00 | 2 | 5 | 7 | 5 |
| P20 | 3,00 | 3 | 3 | 3 | 3,00 | 4,6 | 3,67 | 2 | 8 | 10 | 5 |
| P21 | 2,67 | 3 | 3,2 | 3 | 2,97 | 3,05 | 2,67 | 3 | 5 | 8 | 5 |
| P22 | 2,67 | 3 | 2,4 | 2 | 2,52 | 3,75 | 3,33 | 2 | 8 | 10 | 5 |
| P23 | 1,00 | 1 | 1,8 | 1 | 1,20 | 3,45 | 4,00 | 1 | 8 | 9 | 5 |
| P24 | 1,00 | 1 | 1,8 | 1 | 1,20 | 3,55 | 4,00 | 1 | 1 | 2 | 5 |
| P25 | 4,33 | 4,2 | 4,2 | 4 | 4,18 | 4,1 | 4,11 | 5 | 5 | 10 | 5 |
| P26 | 4,33 | 4,6 | 4,2 | 5 | 4,53 | 3,35 | 4,67 | 5 | 1 | 6 | 5 |
| P27 | 2,00 | 2 | 2,4 | 2 | 2,10 | 3,85 | 3,33 | 2 | 5 | 7 | 5 |
| P28 | 1,33 | 1,4 | 1,8 | 1 | 1,38 | 4,15 | 2,56 | 4 | 5 | 9 | 5 |
| P29 | 4,67 | 4,4 | 4 | 5 | 4,52 | 3,3 | 4,33 | 4 | 5 | 9 | 5 |
| P30 | 2,33 | 2,8 | 2,8 | 2 | 2,48 | 3,05 | 3,11 | 2 | 5 | 7 | 5 |
| P31 | 4,00 | 4,2 | 3,8 | 4 | 4,00 | 4,25 | 4,00 | 4 | 11 | 15 | 5 |
| P32 | 1,67 | 2,2 | 1,8 | 2 | 1,92 | 3,55 | 2,89 | 2 | 5 | 7 | 5 |
| P33 | 3,00 | 3 | 3 | 3 | 3,00 | 3,5 | 2,78 | 1 | 5 | 6 | 5 |
| P34 | 3,00 | 3 | 3 | 3 | 3,00 | 3 | 3,11 | 1 | 5 | 6 | 5 |
| P35 | 2,67 | 2,8 | 2,6 | 3 | 2,77 | 3,2 | 2,67 | 4 | 1 | 5 | 5 |
| P36 | 1,33 | 1,8 | 1,8 | 1 | 1,48 | 3,95 | 2,89 | 4 | 5 | 9 | 5 |
| P37 | 4,00 | 3,8 | 3,2 | 5 | 4,00 | 3,5 | 3,33 | 4 | 0 | 4 | 0 |
| P38 | 5,00 | 4,2 | 4 | 4 | 4,30 | 3,5 | 4,56 | 3 | 5 | 8 | 5 |
| P39 | 3,67 | 3,6 | 3,6 | 4 | 3,72 | 3,6 | 4,11 | 3 | 5 | 8 | 5 |
| P40 | 2,33 | 2,6 | 2 | 3 | 2,48 | 3,05 | 3,44 | 2 | 5 | 7 | 5 |
| Mean | 3,09 | 3,16 | 3,035 | 3,1 | 3,10 | 3,5625 | 3,60 | 3 | 5,075 | 9,295 | 4,875 |
| SD | 1,233 | 1,128 | 0,873 | 1,277 | 1,077 | 0,487 | 0,592 | 1,261 | 2,777 | 3,147 | 0,791 |

## 8.3 Perceived Performance using the Platform

Each question of the Likert-type test was grouped together with its own category of perceived performance, as shown in Table 8.3: creative performance, team performance, usefulness and accessibility. These categories are analyzed in the next subsections.

### 8.3.1 Perceived Creative Performance

Creative performance is related to the expression and the understanding of others' ideas. In Figure 8.2, 30% of users had a neutral position about whether the creativity was stimulated on the platform, with 28% agreeing and 20% strongly agreeing. 10% of the users disagreed and 12% strongly disagreed.

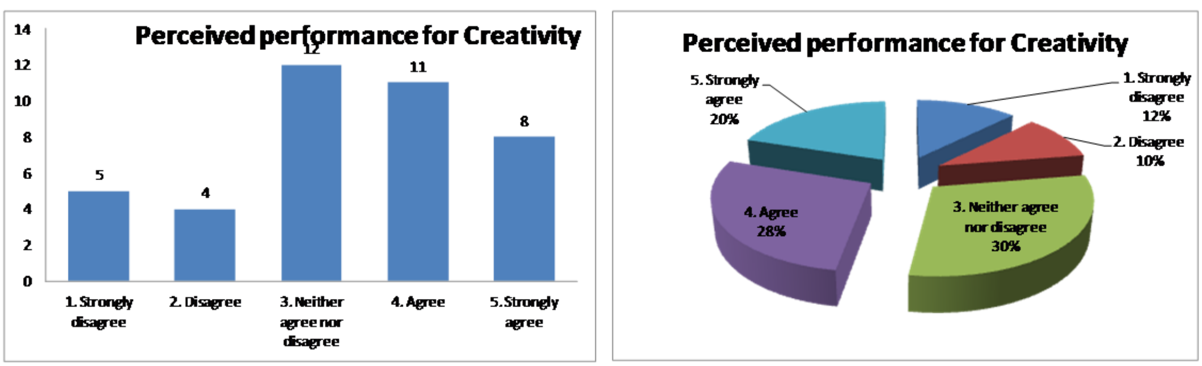



Figure 8.2 Perceived creativity performance using the Platform

### 8.3.2 Perceived Creative Team Performance

Team awareness during a project and its advances are generally very difficult to quantify. As can be seen in Figure 8.3, on the platform, users could perceive how their team works and exchange ideas; they could also form an image of changes and advances in the project. 25% of users strongly agreed with this functionality, 25% agreed, and 35% neither agreed nor disagreed.

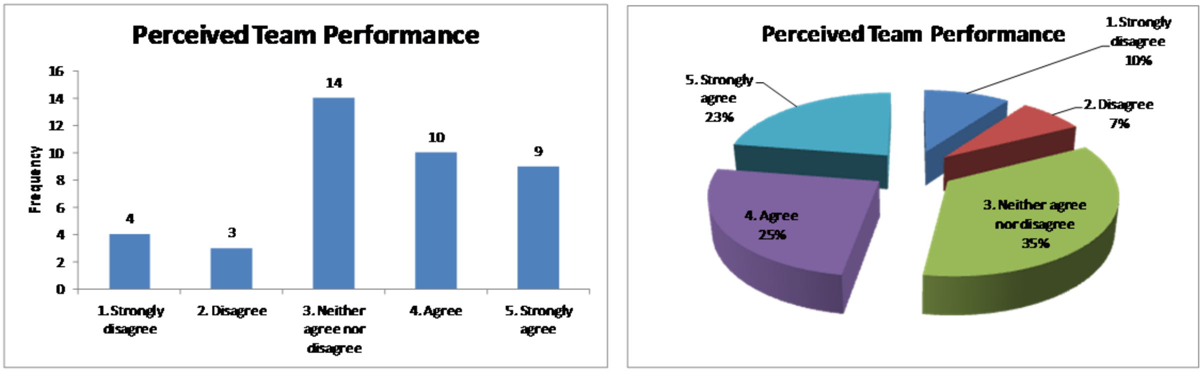



Figure 8.3 Perceived performance using the Platform

### 8.3.3 Perceived Usefulness

Figure 8.4 shows the perceived usefulness of the platform for creative sessions. In this category, 10% of users strongly agreed, while 38% agreed about the usefulness of the platform in their creative work. 30% had a neutral position, and 22% disagreed in this category.

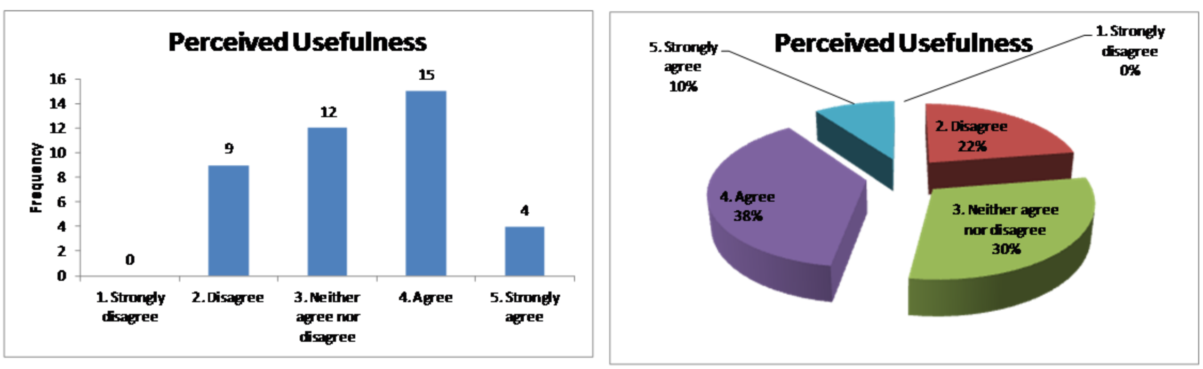



Figure 8.4 Perceived Usefulness using the Platform

### 8.3.4 Perceived Accessibility

Accessibility enables users to connect with different kinds of devices and to have a relative interaction with their custom ICT tools. In Figure 8.5, we see that 15% of users strongly agreed with this feature and 25% agreed, while 30% had a neutral position, and 15% disagreed and 15% strongly disagreed. In terms of accessibility, a collaborative platform must be more compatible with mobile devices like smart phones, tablet computers and portable media players.

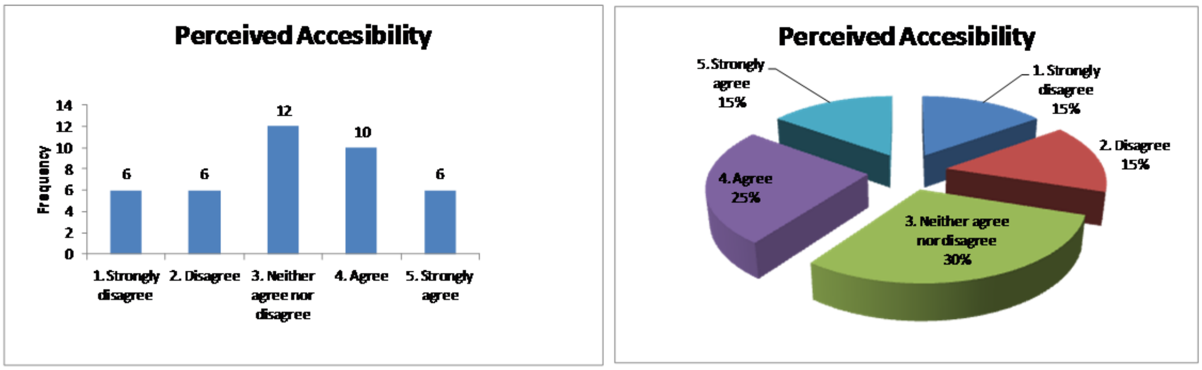



Figure 8.5 Perceived Accessibility to the Platform

## 8.4 Perceived Performance and Groupware Experience

Studies on human performance explain the difficulty of tracing the behavior of users to define their self-perception of performance. This complexity is aggravated and more obvious in groupware or collaborative applications; because there are social variables involved, including teamwork dynamics, communication and user experience in groupware systems. At the end of 24H, we sent an online form about the perceived experience using the prototype. Only 40 users agreed to participate, this increases the margin of error to 15.1%, which at beginning was of 5.0% (267 participants of 882) with a statistical confidence level of 95%.

The data was mined by a correlation analysis, as shown in Table 8.4 and Figure 8.6, to establish some interrelationships among all categories. The first four categories, perceived creativity performance, perceived team performance, usefulness and accessibility, show a high correlation, due to their high interrelationship, as validated by the reliability test (Alpha's Cronbach test, Table 8.1). Moreover, there is an acceptable correlation between the use of groupware and perceived creativity and perceived team performance. Team creative assessment is very weak when correlated with the perceived usefulness of the platform. There is a weak correlation between the use of groupware and the perceived performance and the assessment of a creative team.

Table 8.4 Correlation Analysis of Perceived Performance, Creativity assessment, and Groupware Use

| | *Perceived Creativity* | *Perceived Team Performance* | *Perceived Usefulness* | *Perceived accessibility* | *Total Perceived Performance* | *Individual Creativity Assessement* | *Team creative Assessment* | *Use Groupware* | *Experience using Groupware* | *Total Experience of Use* | *Like working in Teams* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Perceived Creativity* | 1.000 | | | | | | | | | | |
| *Perceived Team Performance* | 0.941 | 1.000 | | | | | | | | | |
| *Perceived Usefulness* | 0.830 | 0.892 | 1.000 | | | | | | | | |
| *Perceived accessibility* | 0.868 | 0.921 | 0.820 | 1.000 | | | | | | | |
| *Total Perceived Performance* | 0.958 | 0.985 | 0.917 | 0.952 | 1.000 | | | | | | |
| *Individual Creativity Assessement* | -0.015 | 0.050 | 0.166 | 0.004 | 0.043 | 1.000 | | | | | |
| *Team creative Assessment* | 0.352 | 0.373 | 0.539 | 0.359 | 0.414 | 0.123 | 1.000 | | | | |
| Use Groupware | 0.522 | 0.494 | 0.340 | 0.446 | 0.480 | 0.192 | 0.046 | 1.000 | | | |
| *Experience using Groupware* | 0.058 | 0.003 | -0.060 | -0.111 | -0.028 | 0.283 | -0.106 | 0.088 | 1.000 | | |
| *Total Experience of Use* | 0.260 | 0.200 | 0.083 | 0.081 | 0.168 | 0.326 | -0.075 | 0.478 | 0.917 | 1.000 | |
| *Like working in Teams* | -0.119 | -0.092 | -0.031 | -0.241 | -0.136 | 0.021 | 0.074 | -0.129 | 0.296 | 0.210 | 1.000 |

We know that a correlation analysis does not validate the relationship between variables, but that it is a highlighter of possible relationships.

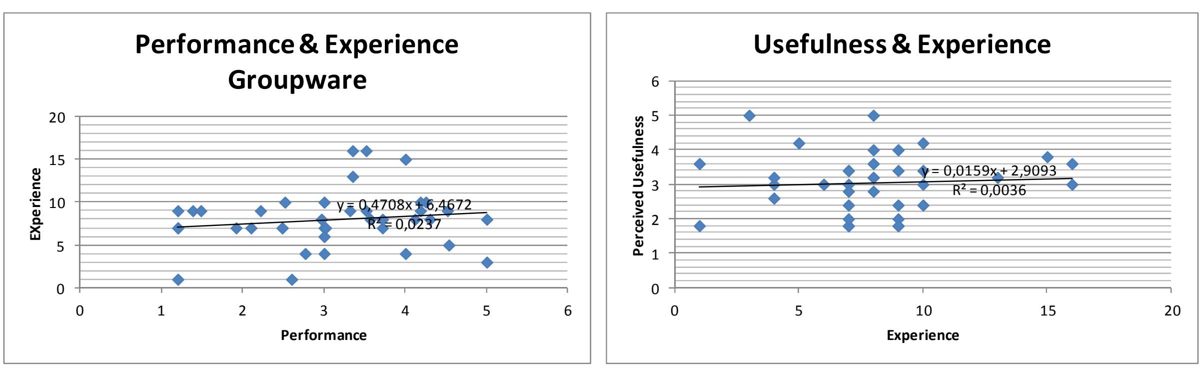



Figure 8.6 Distribution of Perceived performance, Groupware Experience and Usefulness

In our case, the kind of distribution of data as shown in Figure 8.6 and the low number of participants (n=40) who agreed to respond to the last questionnaire, do not enable us to go further in this hypothetical test. However, the following hypothetical tests are proposed to illustrate the possible calculation process but it could not be used as a predictive test.

Observing the data obtained in Figure 8.6, we distinguish three groups that report three levels of competencies in the use of groupware. We grouped the responses of participants according to their level of experience in the use of groupware, as seen in Table 8.5. We find Group 1 with low experience using groupware, Group 2 with medium experience using groupware and Group 3 with high experience in the use of groupware.

Table 8.5 Test participants grouped by level of Groupware utilization

| | Group 1 -Low Use Groupware | | | Group 2- Medium Use Groupware | | | Group 3 - High Use Groupware | | |
|---|---|---|---|---|---|---|---|---|---|
| | **n** | Experience | Performance | **n** | Experience | Performance | **n** | Experience | Performance |
| 1 | **P2** | 0 | 2,6 | **P3** | 5 | 4,12 | **P1** | 11 | 3,35 |
| 2 | **P4** | 0 | 3,00 | **P6** | 5 | 3,00 | **P5** | 11 | 3,52 |
| 3 | **P18** | 0 | 1,2 | **P9** | 5 | 3,57 | **P7** | 5 | 4,25 |
| 4 | **P23** | 8 | 1,2 | **P11** | 5 | 3,72 | **P8** | 5 | 4,18 |
| 5 | **P24** | 0 | 3,0 | **P12** | 5 | 3,00 | **P10** | 11 | 3,35 |
| 6 | **P27** | 5 | 2,1 | **P14** | 5 | 3,02 | **P13** | 5 | 3,32 |
| 7 | **P33** | 5 | 3 | **P15** | 5 | 1,20 | **P16** | 5 | 2,22 |
| 8 | **P34** | 5 | 3 | **P19** | 5 | 1,20 | **P17** | 5 | 3,52 |
| 9 | **P35** | 0 | 2,77 | **P20** | 8 | 3,00 | **P25** | 5 | 4,18 |
| 10 | | | | **P21** | 5 | 2,97 | **P26** | 0 | 4,53 |
| 11 | | | | **P22** | 8 | 2,52 | **P28** | 5 | 1,38 |
| 12 | | | | **P30** | 5 | 2,48 | **P29** | 5 | 4,52 |
| 13 | | | | **P32** | 5 | 1,92 | **P31** | 11 | 4,00 |
| 14 | | | | **P38** | 5 | 4,30 | **P36** | 5 | 1,48 |
| 15 | | | | **P39** | 5 | 3,72 | **P37** | 0 | 4,00 |
| 16 | | | | **P40** | 5 | 2,48 | | | |
| | **Mean** | 2,6 | 2,4 | | 5,3750 | 2,8875 | | 5,9 | 3,4533 |
| | **Mode** | 0,0 | 3,0 | | 5,0 | 3,0 | | 5,0 | 3,4 |
| | **SD** | 3,3226 | 0,7277 | | 2,0586 | 1,0732 | | 3,4731 | 0,9777 |

Comparing the mean and mode, we observe that those with no experience using groupware and with variable experience with projects using groupware had the lowest mean of the other groups. In the same vein, they feel that their performance is lower than that of the other groups. For the analysis of the relationship between the total perceived Creative Performance and the previous experience mentioned in the use of groupware for project development ($r^2$=0.4748), we formulate a hypothesis, where:

$H_0$: $\mu_{experience\ projects} = \mu_{creative\ performance}$ (Null hypothesis)

$H_1$: Users with experience in the use of groupware are going to perceive a high perception of their creative performance of the platform.

In a first step to validate $H_1$, we propose the Student's *t*-test among two paired difference tests, as seen in Table 8.6. The result was t= 5.2446 > t Critical (two tail) 2.0027. $H_0$ is rejected, because there is a low probability that the two variables have a different behavior (less than 5% p-value < 0.05). In line with this result, we confirm that users with previous experience in the use of groupware perceive that the platform conveniently supports their creative performance.

Table 8.6 Student's t-test for Independent samples

| Paired difference test: t-test | | |
|---|---|---|
| | *Experience* | *Performance* |
| Mean | 5.2 | 2.951666667 |
| Variance | 6.830769231 | 1.045638177 |
| Observations | 40 | 40 |
| Pearson Corelation | 0.124117283 | |
| Hypothesized mean difference | 0 | |
| df | 39 | |
| t Stat | 5.294598984 | |
| P(T<=t) one-tail | 2.4624E-06 | |
| t Critical (one-tail) | 1.684875122 | |
| P(T<=t) two-tail | 4.9248E-06 | |
| t Critical (two-tail) | 2.022690901 | |

In addition, we realized an Analysis of Variance (ANOVA) (see Table 8.7) for comparing three groups classified according to their previous experience in the use of software, as shown in Table 8.5. For ANOVA, we obtained a p-value 0.04569 < 1.553 critical f-values, where the formulated hypotheses are:

Table 8.7 ANOVA-test for two-factors without replication

| ANOVA: Two-factors Without Replication | | | | | | |
|---|---|---|---|---|---|---|
| *SUMMARY* | *Count* | *Sum* | *Average* | *Variance* | | |
| G1 | 3 | 4,6 | 1,53333333 | 0,85333333 | | |
| | 3 | 8 | 2,66666667 | 2,33333333 | | |
| | 3 | 5,2 | 1,73333333 | 1,21333333 | | |
| | 3 | 10,2 | 3,4 | 15,88 | | |
| | 3 | 3,2 | 1,06666667 | 0,01333333 | | |
| | 3 | 9,1 | 3,03333333 | 2,90333333 | | |
| | 3 | 9 | 3 | 4 | | |
| | 3 | 9 | 3 | 4 | | |
| | 3 | 7,76666667 | 2,58888889 | 2,2737037 | | |
| G2 | 3 | 12,1166667 | 4,03888889 | 1,00453704 | | |
| | 3 | 11 | 3,66666667 | 1,33333333 | | |
| | 3 | 11,5666667 | 3,85555556 | 1,06259259 | | |
| | 3 | 10,7166667 | 3,57222222 | 2,26564815 | | |
| | 3 | 10 | 3,33333333 | 2,33333333 | | |
| | 3 | 10,0166667 | 3,33888889 | 2,32787037 | | |
| | 3 | 8,2 | 2,73333333 | 4,01333333 | | |
| | 3 | 8,2 | 2,73333333 | 4,01333333 | | |
| | 3 | 13 | 4,33333333 | 10,3333333 | | |
| | 3 | 10,9666667 | 3,65555556 | 1,35592593 | | |
| | 3 | 12,5166667 | 4,17222222 | 11,0556481 | | |
| | 3 | 9,48333333 | 3,16111111 | 2,59453704 | | |
| | 3 | 8,91666667 | 2,97222222 | 3,08564815 | | |
| | 3 | 12,3 | 4,1 | 1,03 | | |
| | 3 | 11,7166667 | 3,90555556 | 1,02675926 | | |
| | 3 | 9,48333333 | 3,16111111 | 2,59453704 | | |
| G3 | 3 | 17,35 | 5,78333333 | 20,4408333 | | |
| | 3 | 19,5166667 | 6,50555556 | 15,7000926 | | |
| | 3 | 14,25 | 4,75 | 0,1875 | | |
| | 3 | 13,1833333 | 4,39444444 | 0,28342593 | | |
| | 3 | 19,35 | 6,45 | 16,2075 | | |
| | 3 | 12,3166667 | 4,10555556 | 0,71675926 | | |
| | 3 | 11,2166667 | 3,73888889 | 1,98787037 | | |
| | 3 | 12,5166667 | 4,17222222 | 0,57231481 | | |
| | 3 | 14,1833333 | 4,72777778 | 0,22231481 | | |
| | 3 | 10,5333333 | 3,51111111 | 4,7837037 | | |
| | 3 | 10,3833333 | 3,46111111 | 3,48787037 | | |
| | 3 | 13,5166667 | 4,50555556 | 0,25009259 | | |
| | 3 | 19 | 6,33333333 | 16,3333333 | | |
| | 3 | 10,4833333 | 3,49444444 | 3,28342593 | | |
| | 3 | 9 | 3 | 3 | | |
| Use Groupware | 40 | 117 | 2,925 | 1,66089744 | | |
| Experience | 40 | 208 | 5,2 | 6,83076923 | | |
| Performance | 40 | 118,066667 | 2,95166667 | 1,04563818 | | |
| ANOVA | | | | | | |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F Critic* |
| Sample | 163,657185 | 39 | 4,19633808 | 1,57137772 | 0,04569051 | 1,55323857 |
| Columns | 136,417852 | 2 | 68,2089259 | 25,5417901 | 2,9358E-09 | 3,11379226 |
| Interaction Within | 208,297704 | 78 | 2,67048338 | | | |
| Total | 508,372741 | 119 | | | | |

H$_0$: $\mu_{experience\ projects} = \mu_{creative\ performance} = \mu_{use\ of\ groupware}$ (Null hypothesis)
H$_1$: Users with experience in the use of groupware are going to perceive a high perception of their creative performance on the platform, and also they have a high experience in the use of groupware. With these results, H$_0$ is rejected. Therefore, users having more experience in the use of groupware perceive that they are more efficient (creative performance) on the platform. These results indicate that users with previous experience in the use of groupware are able to perceive an improved performance related to developing creative projects.

Additionally, a user who has more experience using groupware or ICT tools could tend to evaluate his/her performance on the platform as being higher. The results of ANOVA also indicate that satisfaction with the creative teamwork performance has an incidence on the satisfaction with the use of the platform. In this variable, we assume that the activities realized and the kind of ambience obtained for creativity inside the team has an influence on the perception of that wellness in the use of the collaborative platform.

### 8.5 Usability: qualitative Evaluation of the collaborative experience on InnoKiz

The Likert-type test was accompanied by an open-question form for enquiring about the low-rated questions. The questions were:
1) Can you describe the main reason for giving a low score? Please, feel free to explain your response.
2) Why do you use InnoKiz? Which functionalities were used?
3) Do you need another resource to complete your creative work?
4) Do you use creative methods? Are they useful for your project? Which one do you use? Please give the name.
5) Did you find obstacles to obtaining a "perfect" collaboration with your team?

The open-questions were answered by 17 of 40 participants (42%). The sample might seem small, however Nielsen and Landauer (1993) affirm that more of 15 users provide the necessary information about the occurrence of problems in the design of a new interface, product or system, because the data are set out according with Poisson distribution. The qualitative analysis was conducted summarizing and grouping the users' answer by categories, as shown in Table 8.8. The answers obtained explained the problems or limitations with InnoKiz. We classify them in eight categories: 1) No perceived need to use it, 2) Human Factors (ergonomics), 3) Training needs, 4) No perceived efficiency or a feeling of a waste of time, 5) Knowledge Management information needs, 6) Not a habitual tool, 7) Difficult to use and 8) Need for other communication tool.

Table 8.8 Qualitative Evaluation of InnoKiz: problems and limitations

| **Problem/Limitation** | **No perceived need to use** | **Human Factors - Browsing** | **Training needs** | **Not efficient or Waste of time** | **Knowledge Management - Information** | **Not habitual tool** | **Difficult to use - Complicated Tool** | **Need communication tools** |
|---|---|---|---|---|---|---|---|---|
| - Non-use of InnoKiz for colocalized team | 1 | | | 1 | | | | |
| - Low design quality (Human Factors) | | 1 | | | | | | |
| - Unfamiliarity | | | 1 | | | 1 | | |
| - Teams non see necessary the utilisation | 1 | | | | | | | |
| - Team feel a waste of time using a platform | | | | 1 | | | | |
| Limitations to understand the information exchanged | | | | | 1 | | | 1 |
| - Not necessary complete information | | | | | 1 | | | |
| - Not interesting to see the guide | 1 | | | | 1 | | | |
| - It is not easy incorporate information | | 1 | | | 1 | | | |
| - Other platform more easy and on basic diary use (Dropbox) | | | | | | 1 | | 1 |
| - Not efficient | | | | 1 | | | | |
| - Not intuitive and complicate | | 1 | | | | | 1 | |
| - It lacks of a system of file sharing (Dropbox) or T-chat for brainstorming | | | | | | 1 | | 1 |
| - Local environment peaceful | 1 | | | | | | | |
| - The system is rigid | | 1 | | | | | 1 | |
| - Low response reaction | | 1 | | | 1 | | | |
| - It lacks a chat service to facilitate brainstorming | | | | | | 1 | | 1 |
| - The idea presentation tool is very complete (even a little too much) | | | | | 1 | | | |
| - Difficult to use | | 1 | | | | | 1 | |
| - Complicated interface | | 1 | | | | | 1 | |
| - Difficult to browse inside the Platform | | 1 | | | | | 1 | |
| - Difficult to distinguish functionalities | | 1 | | | | | | |
| - Difficult to update information | | | | | 1 | | | |
| **Categories Total** | 4 | 9 | 1 | 3 | 7 | 4 | 5 | 4 |
| **Number of commentaires** | 6 | 2 | 1 | 2 | 3 | 3 | 5 | 2 |
| **Main limitations = Categories*Comments/2** | 12 | 9 | 1 | 3 | 11 | 6 | 13 | 4 |

Analyzing user's responses, we found essentially that participants who worked in co-localized spaces with their teams do not see the importance of use the platform (participant

P2, P12, and P22 -see Appendix III), unless their organization imposes the use of a tool. In this case, the use of InnoKiz was imposed for the registration and to post the result (a video presentation). Also, the organization sent messages and information about the competition, and participants found it very interesting to follow the competition and the other teams. De-localized participants declared that the platform was useful, while 58% of 40 participants agreed and strongly agreed with the use of the platform. In particular, they were aware of the competition and also they were interested in seeing their own team progress.

As seen in Figure 8.7, the most common problems are closely related to the difficulties in the use of Innokiz because there are a lot of functions (22%), 16% with problems to browsing information on the platform (Human Factors-Ergonomics), and 18% with problems related to the management of knowledge on the information handled on the platform. 21% did not perceive the need to use the platform because they work in a co-localized manner. 10% stated that they needed more time to become familiar with the platform (formation and training time). 7% needed more ICT tools like chat or Video streaming functionalities as well as a file sharing system like Dropbox. 5% of users were not satisfied with using the platform because they believed that it was a waste of time. 1% expressed the need for more time to train. For participants, there was a lack of information and of explanation about the Platform, and so training in the use of the platform is a very important step.

## 8.6 How can collaboration be achieved on the Platform?

In the online form, participants were questioned about what elements were needed to produce a successful collaboration experience among teammates and inside InnoKiz.
We summarized their responses below in terms of new collaboration features to be added to the platform:

- Communication tools such as Instant messages or Chat among teammates and all participants (community)
- File Sharing System, to exchange files as the team proceeds with the project
- Reactive response from others participants and the system

- Searching and Knowing teammates' competencies
- Simplicity in browsing for all activities: idea selection and project progress
- More intuitive tools, and
- Mind-mapping tools (using a tool as a brainstorming or conceptual map using post-it, but in the team space)

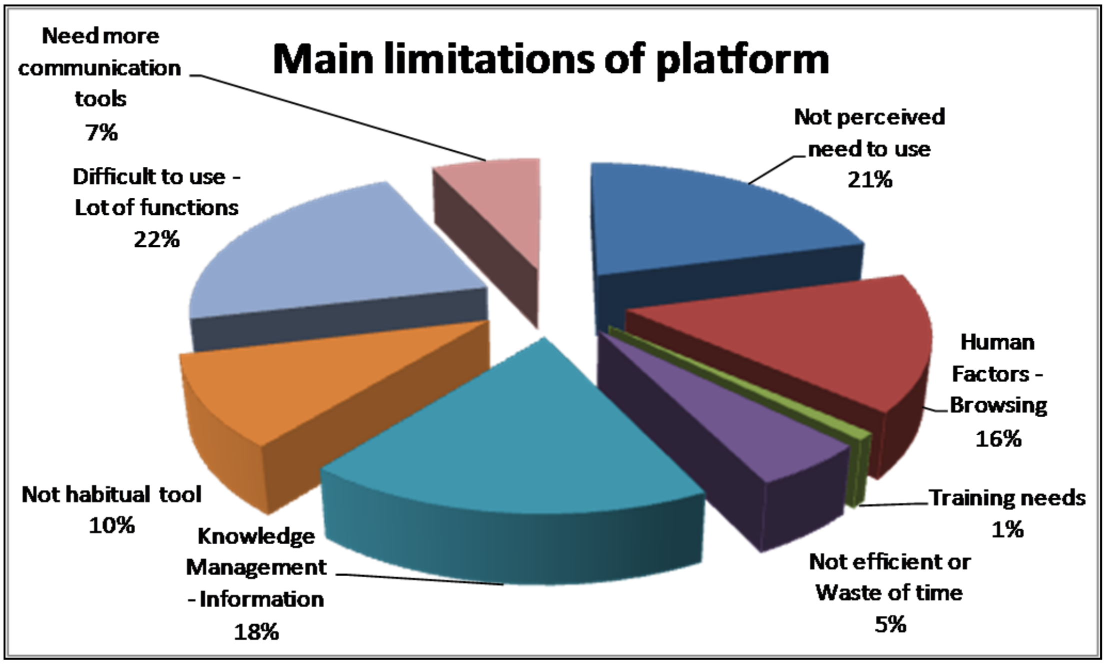



Figure 8.7 Limitations observed in the Platform by users

## 8.7 Summary

In this chapter, we have analyzed the perceived creative performance reported by users of the collaborative platform prototype. The results obtained indicate that there is a correlation between perceived performance in the use of InnoKiz and previous experience in the use of groupware, and also, previous experience in project development. 58% of the 40 participants that evaluated InnoKiz agreed and strongly agreed with the use of the platform for creative activities. Meanwhile, the lowest score was given for the usefulness category, with 22% of the participants not finding the platform useful in co-localized conditions. Comparing mean differences by two statistical tests, we analyzed three variables: previous experience in project development, the use of groupware, and creative performance. The collaborative performance was assessed by four measures: perceived creative performance, perceived team performance, perceived usefulness, and perceived accessibility (Chapter 8). On average, all factors obtained 3.1 out of a maximum score of 5.0, and 9% of participants disagreed with at least one factor. We compare these results with other measurements of creative assessment and groupware experience. Factors such as individual creative assessment and creative team performance were measured using the creative assessment of VanGundy (1984). Results showed a very weak correlation ($r^2 = 0.54$) between creative team performance (VanGundy, 1984) and perceived usefulness of InnoKiz. However, applying other statistics tests such as ANOVA, and classifying three groups by previous experience in the use of groupware. The results showed that:

- The previous experience in creative projects increases the perception of usefulness of the platform.
- The previous experience using groupware increases the perception of the creative performance.

We conclude that the importance of developing previous training and practice in ICT tools, should improve the experience in collaborative platforms. Communication is a basic need for all participants, and they expressed the need for more communication tools, particularly instant messages or chats between teams and the community, as well as more intuitive functionalities and a friendly file sharing system to complete the collaboration experience in the Platform.

# CONCLUSION

This thesis considered the research question: ***How is it possible to support distributed creative collaboration through a knowledge management system and a collaborative ICT platform for ideas and knowledge sharing?*** In the current state of art of ICT, a new functionality may appear and be capable of adding a new improvement, a new practice regarding how people communicate and work, although it is still difficult to exactly forecast the future of Web Tools and their application to creative activities. For that reason, this thesis has proposed the design of a Platform that supports the creative collaboration of more sensible informal and tacit knowledge exchanges, based on an expert Knowledge Management System (KMS) that interacts with creative teams. This is one of the main findings of our research, the proposition of a new KMS to support a free association of ideas, their codification and their valorization (as presented in Chapter 5) among team members and external partners. Due to the need to achieve an innovation, the creative teams has to: 1) acquire a shared expertise in strategic collaboration activities (Chapter 2) and 2) capture ideas and knowledge that is distributed among team members (Chapter 4).

This thesis has presented an analysis of current collaborative ICT technologies which still need the development of new functionalities to boost the exchange of strategic knowledge (most of the time tacit knowledge). We also developed new functionalities such as the "Collaborative tagging" and the "Graphic folksonomy" to codify the process of idea sharing that consist in: associating, commenting, criticizing, selecting, and sponsoring by subject matter or by knowledge field  of the idea sharing process (Chapter 6). In the design of the Platform, we considered capturing the knowledge provided by the external partners and community by comments or by votes. Capturing external knowledge is an advantage for creative teams. This dynamic produces a new form of product development oriented to innovation, in which the knowledge localized outside the team is brought closer. This cross-functional collaboration harnesses a new use of ICTs in product development, according to the new economic trends in which "information technology has opened a whole new opportunity for manufacturers to offer customized products faster, cheaper, and more cost effectively using "build-to-order" also, a "variety of options enabled by mass customization" (Prahalad and Ramaswamy, 2004, p. 43).

Remote teams (19%) and co-localized teams (30%) used the prototype differently. The remote teams used the new functionality "Collaborative tagging" to display and evaluate ideas. While co-localized teams receive comments and contribution of external partners (free association) and public comments, votes and contributions. This result supports the fact that previous personal interaction is very important for stimulating creative contributions and also, the collaborative platform is also useful for co-localized teams (Chapter 7).

The collaborative performance was assessed by four measures: perceived creative performance, perceived team performance, perceived usefulness, and perceived accessibility (Chapter 8). On average, all factors obtained 3.1 out of a maximum score of 5.0, and 9% of participants disagreed with at least one factor. We compare these results with other measurements of creative assessment and groupware experience. Factors such as individual creative assessment and creative team performance were measured using the creative assessment of VanGundy (1984). Results showed a very weak correlation ($r^2 = 0.54$) between creative team performance (VanGundy, 1984) and perceived usefulness of InnoKiz. However, applying other statistics tests such as ANOVA, and classifying three groups by previous experience in the use of groupware. The results showed that:

- The previous experience in creative projects increases the perception of usefulness of the platform.
- The previous experience using groupware increases the perception of the creative performance.

The results allow us to conclude that creative teams need to have previous training in the use of collaborative platform (skills to use groupware system). This training could be integrated into creative technique sessions in order to harness idea sharing or idea evaluation. These findings will be addressed in future research, in which we will focus on creative collaboration in more complex systems to support the whole development of the cross-platform.

## CONTRIBUTION, FINDINGS AND ORIGINALITY OF THE RESEARCH

### Contribution

This thesis proposes an integrated model of Knowledge Management System (KMS), based in the knowledge production and the incorporation of technology tools. This KMS harnesses the advantages of ICT to support the tacit knowledge of creative activities.

The prototype of the platform has supported the new functionalities proposed:

- Generating a free-association among participants (by domain or subject and by team) to produce a team and an extended network;
- Generating a free-association for new team creation;
- Aggregating tools of knowledge acquisition using Internet and Communication tools, creative teams prefer Internet support, in the form of technology watch. This method permits a constant comparison between the state-of-the-art of current technology and the process of product conceptualization;
- Visualizing tacit knowledge by collaborative tagging and ideas evaluation;
- Tracking ideas and its evaluation (Graphic Folksonomy).

The findings are presented by subject and respective chapter:

### Chapter 1: Innovation Models

- Knowledge Objects in creative collaboration for a new product design
- Reviewing innovation models and the ICT role in support creative collaboration

### Chapter 2: Context for R&D teams

- For R&D teams the transformation of tacit knowledge into codified knowledge does not produce new knowledge. It is the continuous discussion and "shared expertise" with a strategic purpose that generates new ideas that are codified once the team arrives to start an operative activity.

- The network surrounding R&D is as important as internal team work.
- Free-informal association is the main external source of knowledge
- The knowledge is embedded in expert thinking and is tacit in the first stage.
- A KMS for innovation is composed of experts and the technology support of ICT. ICTs have a high impact on the innovation process, because they ease the informal network needed for innovation.

**Chapter 4: Needs of creative teams**

- Creative teams need a wide range of ICT tools; the use of the Internet and communication tools, in particular, other tools such as CAD or specialized design software
- Internet and mind-mapping (ICT) are media used to represent this process during design. Only at the end of the project the creative teams use more specialized software to codify their ideas.

**Chapter 5 and 6: Modeling an ideal ICT Platform**

- The platform supports the useful functions of ICT: networking conformation for unknown knowledge capture, team integration, visualization of personal contributions and ideas and known knowledge tracking.
- The ideal platform produces this interaction through four new functionalities: emoticons, collaborative tagging, free team creation, and idea space.

**Chapter 7: Uses and interaction with the InnoKiz Prototype (Chapter 7)**

- The uses case proposed were accepted by the users as much for colocalized and delocalized teams (registration, team conformation, use of idea space, tagging and evaluation system)
- The tagging of ideas system was used to codify ideas information: concepts, needs and description.
- The functionalities used corresponding directly to the instructions presented by the organization.

**Chapter 8: Creative Collaboration Performance and Usability**

- In the design and use of a collaborative platform, user's satisfaction is enhanced by creating a complementary interaction between the Platform KMS and the participants' needs, and not solely in the aggregation of tools.
- The participants that have experience in project development and ICT experience (groupware use) were satisfied in the use of the Platform.

## Thesis originality

The originality of this thesis lies in the proposition of an integrated model of Knowledge Management System (KMS). This KMS harnesses new functionalities that are useful for creative activities of R&D teams. Also, this thesis overcomes the lack of methodology and testing instruments in creative collaboration. The prototype and the results of this research are subject of a process of intellectual protection (by the Research and Innovation Support Services Office of ÉTS) and the publication of the following works:

### Papers

- Jiménez-Narváez, L.-M., & Gardoni, M. (2014). Developing design concepts in a cloud computing environment: creative interactions and brainstorming modalities. *Accepted to Journal of Digital Creativity*.
- Jiménez-Narváez, L.-M., Segrera, A., & Gardoni, M. (2012). Opportunities and Limitations of the Cloud Computing Environment: In the Early Stage of Design Process. *International Journal of Design Principles and Practices, pp 1-18*.
- Jiménez-Narvaez, L. M., & Gardoni, M. (2011). Reflections on creative and collaborative teamwork. *Journal of research in interactive design*, 3 (Springer).

### Submitted Papers (waiting answer)

- Jiménez-Narváez, L.-M., Labelle, I., Choulier, D., Legardeur, J., & Gardoni, M. (2012). Harnessing Creative Teamwork and Leadership in Quick-Term Project Devel-

opment (QPD), 24 Hours of Innovation® (24H). Submitted to *Research in Engineering Design*.

- Jiménez-Narvaez, L.-M., & Gardoni, M. (2013). *Collaborative knowledge-based networking for innovation among R&D firms: Analysis of Canadian Case"*. École de technologie supérieure. Submitted *Innovar*

**Conferences**

- Jiménez-Narvaez, L.-M., Segrera, A., Dalkir, K., & Gardoni, M. (2013). *Harnessing Experiential Learning on remote co-design experiences: 24 hours of Innovation*. Paper presented at the Engineering Leadership in Innovation and Design Conceive Design Implement Operate CDIO'2013 MIT/Harvard, Cambridge, MA.
- Jiménez-Narvaez, L.-M., Dalkir, K., & Gardoni, M. (2013). *Harnessing IT on Innovation Projects. Managing remote co-design experiences from 24 hours of innovation*. Paper presented at the PICMET, 2013, San Francisco.
- Jimenez-Narvaez, L. M., Dalkir, K., & Gardoni, M. (2013). *Harnessing social media and Cloud-computing Technologies for Co-design in an Open-Collaborative Innovation: the case of 24 Hours of Innovation*. Paper presented at the International Conference on Engineering Design, ICED'13, Seoul.

-Jiménez-Narváez, L.-M., Dalkir, K., & Gardoni, M. (2012, July 29th - August 2nd). *Harnessing computing technologies within innovative Quick-term Project Development QPD - case study of 24 Hours of Innovation at ETS-Montreal, November 2011.* Paper presented at the Portland International Conference on Management of Engineering & Technology, Vancouver.

- Jiménez-Narváez, L.-M., Dalkir, K., & Gardoni, M. (2012, 9th-11th July). *Managing knowledge needs during new product lifecycle design on Quick-term Project Development QPD: case study of 24 hours of innovation –ÉTS Montreal.* Paper presented at the 9th International Conference on Product Lifecycle Management, Montreal.
- Jiménez, L. M., Choulier, D., Legardeur, J. & Gardoni, M. (2011) Creative Teamwork in Quick Projects Development QPD, 24 Hours of Innovation. International Confer-

ence on Engineering Design, ICED'11 15 - 18 August 2011, Technical University of Denmark (First 5% Mention)

- Jiménez, L. M., Desrosiers, S. & Gardoni, M. Creative teamwork in quick and long term project development, 24 hours of innovation (2011) Symposium on Models and Modeling Methodologies in Science and Engineering (MMMse 2011) to be held in Orlando, USA, on July 19th - 22nd, 2011
- Jiménez, L.M. Analyse par métaphores : une proposition de classification des technologies de soutien au design collaborative. Journee MATI-Montreal.
- Jiménez, L. M., & Gardoni, M. (2010, Octobre 20-22 ). Reflections on creative and collaborative teamwork in charrettes, 24 hours of innovation. Paper presented at the IDMME - Virtual Concept 2010, Bordeaux - France.

**Reports**

- Jiménez-Narvaez, L. M., Gardoni, M., & Dubois, M. (2013). État de l'art des outils et des plateformes utilisées par le secteur spatial pour faciliter l'échange de connaissances M(IES)2C Mesure des impacts sur l'économie et la société des investissements dans l'expertise spatiale au Canada. Montréal: Agence Spatiale Canadienne, HÉC, École Polytechnique, École de Technologie Supérieure.
- Jiménez, L. M. (2012). Étude des parties prenantes : Les entrepreneurs. In É. d. t. s. Mosaic - HÉC (Ed.), *Conceptualisation d'un Hub de Créativité au Planétarium Dow à partir de l'expérience de l'École d'été en management de la création 2012*. Montréal: École de technologie supérieure, Mosaic - HÉC.
- Jiménez, L. M., & Faucher, M.-F. (2012). Étude des parties prenantes : Les experts de Barcelona. In M.-H. École de technologie supérieure (Ed.), *Conceptualisation d'un Hub de Créativité au Planétarium Dow à partir de l'expérience de l'École d'été en management de la création 2012*. Montréal: École de technologie supérieure, MOSAIC - HÉC Montréal.
- Jiménez, L. M., Kitimbo, I., & Dubois, M. (2012). Écosystème du Hub de Créativité de Montréal. In M.-H. École de technologie supérieure (Ed.), *Conceptualisation d'un Hub de Créativité au Planétarium Dow à partir de l'expérience de l'École d'été en*

*management de la création 2012*. Montréal: École de technologie supérieure, Mosaic - HÉC Montréal.

- Jiménez-Narvaez, L.-M. (2010). *Réflexion sur le modèle d'intégration des arts et de la technologie dans la ville créative.* G. Langlois & É. Pawlak (Eds.), *22@Barcelona: Une expérience à réinventer pour le Quartier de l'Innovation de Montréal.*

**Mention of research work in public media**

Messier, Charles 2012. « L'informatique dans les nuages change les habitudes ». *Magazine Jobboom* (Montreal). May, 23th. < http://www.jobboom.com/carriere/l-informatique-dans-les-nuages-change-les-habitudes/ >.

**InnoKiz as spin-off of École de tecnologie supérieure**

InnoKiz, the prototype of the collaborative platform developed during this research, has interesting features that have surpassed our initial expectations, for the following reasons:

- InnoKiz supported more than 800 participants that interacted on the platform in May, 2012 and more of 1000 participants in May, 2013. This intectactive characteristic of InnoKiz had positive effects for "Les 24 heures de l'innovation" competition by allowing an effective exchange for distributed teams around the world (17 sites) and opening the collaboration among the École de technologie supérieure to an international audience and industrial partners.

- InnoKiz is an open resource for the community and public in general, as well as a closed space for teamwork. This feature promotes the initial theory of supporting participants by creative contributions in a dynamic of free association, and provides the possibility of finding external expert's contribution (promoting external knowledge collaboration). It also creates an internal dynamic of creative teamwork.

InnoKiz is a cloud application which supports all creative processes. After a deep discussion with Clément Jacquot, co-developer of the platform, and considering the main research findings of this thesis, the following design decisions were established:

- InnoKiz supports the community in general, through the personal contribution of each participant. For this reason, each participant in InnoKiz is identified in order to create confidence among teammates. This can create a stronger long-term relationship for creative free-association networking.

- InnoKiz also supports all creative methods, as well as all creative processes. The KMS for innovation is produced by each individual contribution (external and internal to the creative team) that is integrated or added to the team space, and for this reason, InnoKiz must enable the free sharing of ideas.

- InnoKiz supports idea sharing starting, from representation or content creation to idea evaluation. This entire dynamic should be available for a clear and transparent collaborative process.

## RECOMMENDATIONS AND FURTHER RESEARCH

In this section, we summarize the main practical issues to take into account in promoting creative collaboration, using ICT technologies. Particularly, these recommendations describe some mechanisms to enhance collaboration: 1) the performance of a creative team depends of individual ideas' contribution, but also as much important is applying strategies and a process of synchronizing (tuning in), integrating or selecting these contributions. 2) ICT as social media tools could reduce the ambiguity in the product definition and new team integration by means of knowing the role of each participant in the team and at the same time, the ideas that each participant has of the product to be developed; 3) Thus, we recommend the visualization of this social system of ideas, skills and contribution ownership tracking to produce an environment more secure to collaborate.

Analyzing the sources of collaboration for innovation (Chapter 2), we found that R&D SME and creative teams need exchanges with their competitors, associates, as well as the Internet, in a clear open innovation model. This contrasts with the closed innovation model, commonly found in the industrial sector, where the new product definition is an industrial secret, without an external connection. This interrelationship between teams and their context requires specific knowledge management strategies centered on ideas and knowledge sharing. We recommend a techno-social system with a flexible open-close function between the team and their context. This social relationship should be defined before any ICT implementation. Also, this social dynamic implies the utilization of social networks, social events and community exchanges, which will be applied in parallel with the knowledge management system. In addition, creative teams need a wide range of ICT tools, especially the Internet, to carry out research on the state-of-the-art of a new technology. This informational condition defines the need for a controlled remote space for ideas and knowledge exchange, even for co-localized teams. The collaborative platform must include the pathway of Web Page links to be shared with the team. Also, we recommend adding application to management the timing and to keep participants aware of changes, deadlines and some performance statistics: idea production numbers, votes, evaluation results, feedback in comments, etc. Creative teams need to perceive tacit knowledge changes efficiently in order to define their ideas.

**Future Research Work**

The results obtained in this thesis highlight certain functionalities of the collaborative Platform that have to be explored, such as collaborative tagging and the impact of the evaluation of ideas on the innovation process. It still remains to study the impact of codification process in the use of ICT for ideas sharing.  Particularly, we highlight this point, because the ideas' codification, as we had observed is not a process realized frequently with non- ICT tools used in co-localized conditions. The last results of the user experience test (Chapter 8) aim to improve some functionalities of the Platform that need to be redefined. Moreover, the introduction of new KMS support is based on spontaneous contributions aggregated in open collaborative projects, or includes guidance for users that need implementing structured creative methods like TRIZ[7], ASIT[8] or C-K[9].

Finally, InnoKiz proposes a new interaction among communities and industry that needs to be explored, and represents a good challenge to be undertaken.

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[7] TRIZ, from the Russian acronym ARIZ (Altgoritm Reshenia Izobretatelskih Zadach) is the Theory of Inventive Problems Solving proposed by Genrikh Altshuller in 1946. Altshuller studied more than 1000 patents to identify the ARIZ algorithm and 40 principles of contradiction used by inventors Semyon, D. Savransky, et Semyon D. Savransky. 2000. *Engineering of creativity : introduction to TRIZ methodology of inventive problem solving*. Boca Raton, Flor.: Boca Raton, Flor. : CRC Press..

[8]Advanced Systematic Inventive Thinking, ASIT: "This method 'manipulates' concrete or abstract things with the same end: resolving rephrased problems in order to find innovative solutions. It tackles all kinds of subjects/issues (e.g. physical, organizational, procedural, etc.) and offers a set of tools for defining contradictions, solving problems and selecting solutions". Available, April, 25, 2013 at :
http://create2009.europa.eu/fileadmin/Content/Downloads/PDF/Projects/National_projects/FR_ASIT_method_of_creative_resolution.pdf

[9] C-K, Concepts and Knowledge, is a method of reasoning on design to define the limits between the concepts and the knowledge of a new product. Method developed by Hatchuel and collaborators. Hatchuel, Armand, et Benoît Weil. 2002. « La théorie CK: Fondements et usages d'une théorie unifiée de la conception. ». In *Colloque «Sciences de la conception»*. (Lyon, France, 15-16 mars).

# APPENDIX I

## ETHICAL PLAN CONSENTMENT AND INFORMATION FORM

Le génie pour l'industrie

FORMULAIRE D'INFORMATION ET DE CONSENTEMENT
Analyse des activités et le support pour les équipes qui réalisent projets innovateurs lors de la compétition internationale 24 heures de l'innovation

**IDENTIFICATION**

Responsable du projet : Mickaël Gardoni
Département : Génie de la Production Automatisée
Adresse postale : École de technologie supérieure. Local A-3588, 1100 rue Notre-Dame Ouest, Montréal (Québec) H3C 1K3
Adresse courriel : mickael.gardoni@etsmtl.ca
Membres de l'équipe : Luz Maria Jiménez, Shuaib Qureshi, Mario Dubois, Pierre Gignac,

**BUT GÉNERAL DU PROJET**

Cette recherche déterminera les besoins en information et en matériel informatique des équipes qui font un projet innovateur à distance. Cette recherche se réalise en parallèle de la compétition internationale des « 24 heures de l'innovation ». Au cours de cette recherche, nous essayons de spécifier un environnement informationnel et informatique qui pourrait notamment supporter les « 24h de l'innovation » dans les prochaines éditions ou tout projet équivalent.
Pendant le déroulement de la compétition, notre équipe de recherche proposera des questionnaires en ligne et un entretien. Vos réponses nous permettront mieux comprendre les outils de support aux projets à distance.

**PROCÉDURE**

Vous recevrez ce courriel d'invitation, à la suite de votre inscription en ligne à la compétition « 24h de l'innovation » (qui a lieu entre le 23 et le 24 mai, 2012).
Lisez attentivement le présent document, si vous êtes d'accord pour participer à la recherche, nous vous invitons à cocher la casse d'acceptation (ci-dessous) et à nous donner votre courriel pour que nous puissions vous recontacter.

Pendant la compétition, notre équipe de recherche vous enverra un courriel avec les liens des formulaires à remplir en ligne. En moyenne vous prendrez 2 minutes pour remplir un questionnaire tous trois heures. À la fin, de la compétition un des membres de l'équipe de recherche pourrait vous contacter pour vous demander votre avis sur les outils et l'environnement informatique utilisés. Veuillez noter que cet entretien pourrait être enregistré (audio -numérique), il aura une durée d'environ 10 minutes.

**AVANTAGES**

Comme participant vous pourrez avoir une meilleure compréhension des activités et des étapes qui interviennent dans la réalisation d'un projet axée sur l'innovation. Aussi, vous utiliserez des outils informationnels ou informatiques qui pourront améliorer les conditions ou les stratégies du travail créatif en équipe dans la formulation de nouveaux produits ou services. Ces connaissances vous seront utiles dans votre carrière professionnelle.

**RISQUES ET INCONVÉNIENTS**

La participation à cette recherche ne présente aucun risque pour votre sécurité. Pour la protection de vos renseignements personnels, l'équipe de recherche s'engage conformément à la Loi sur l'accès aux documents publics et la protection des renseignements personnels, à ne pas divulguer votre courriel en aucun cas.

**CONFIDENTIALITÉ**

Après avoir reçu vos informations sur les formulaires en ligne, vos renseignements personnels : nom, prénom et votre adresse courriel seront remplacés par un code qui vous identifiera. Le fichier numérique contenant le code assigné et vos informations sera conservé dans un ordinateur sous un mot de passe dans le bureau du professeur Mickaël Gardoni pendant 5 ans après ce temps, la liste d'encodage sera détruite. Les données numériques produites et l'enregistrement audio numérique seront stockés sous clé et mot de passe dans l'ordinateur du laboratoire de recherche en maintenant en tout le temps votre anonymat par le responsable du projet et elles seront utilisées uniquement que pour la recherche.

**PARTICIPATION VOLONTAIRE ET DROIT DE RETRAIT**

Votre participation à ce projet est volontaire. Cela signifie que vous acceptez de participer au projet sans aucune contrainte ou pression extérieure, et que par ailleurs vous êtes libre de mettre fin à votre participation en tout temps au cours de cette recherche. Dans ce cas, les renseignements recueilles seront détruits.

Votre accord à participer implique également que vous acceptez que l'équipe de recherche puisse utiliser aux fins de la présente recherche (articles, conférences et communications scientifiques) les renseignements recueillis à la condition qu'aucune information permettant de vous identifier ne soit divulguée publiquement.

**COMPENSATION FINANCIÈRE**

Aucune compensation ne sera offerte.

**DES QUESTIONS SUR LE PROJET OU SUR VOS DROITS?**

L'étude est réalisée par le professeur Mickaël Gardoni, vous pourrez le rejoindre en tout temps au local A-3588 de l'École de technologie supérieure ou sur place de la compétition internationale, par téléphone (514)396-8595 ou par courriel mickael.gardoni@etsmtl.ca
Aussi, vous pouvez contacter à Luz Maria Jiménez au local A-3754 de l'École de technologie supérieure ou sur place de la compétition internationale, par téléphone (514) 396-8800 poste 7260 ou par courriel lmjimenezn@gmail.com

Le Comité d'éthique de la recherche avec des êtres humains de l'ÉTS a approuvé ce projet de recherche auquel vous allez participer. Pour toute autre question concernant vos droits en tant que sujet de recherche, vous pouvez contacter le président du Comité d'éthique de l'École de technologie supérieure au (514)396-8829.

**REMERCIEMENTS**

Votre collaboration est essentielle à la réalisation de notre projet et l'équipe de recherche tient à vous en remercier. Si vous souhaitez obtenir un résume écrit des principaux résultats de cette recherche, veuillez ajouter vos coordonnées ci-dessous.

**SIGNATURES**

Je, soussigné(e)________________________________ reconnais avoir lu le présent formulaire de consentement et consens volontairement à participer à ce projet de recherche. Je reconnais avoir disposé de suffisamment de renseignements et du temps nécessaire pour réfléchir à ma décision. Je comprends que ma participation à cette recherche est totalement volontaire et que je peux y mettre fin en tout temps, sans pénalité d'aucune forme, ni justification à donner. Le cas échéant, je m'engage à prévenir le responsable du projet.

Je confirme que j'accepte les conditions de cette recherche en validant mon accord sur l'onglet je suis d'accord. Je comprends que je ne renonce aucunement à mes droits ni ne libère le(s) chercheur(s) de leurs responsabilités légales et professionnelles.

J'accepte participer au projet de recherche sur les 24 heures de l'innovation

Oui ____ Non ______

Nom et coordonnées du participant :

Adresse courriel :

Date :

Je, soussigné(e) ________________________________ certifie avoir expliqué au signataire intéressé les termes du présent formulaire, avoir répondu à ses questions et lui avoir clairement indiqué son droit de mettre fin à son engagement en tout temps. Je lui transmettrai une copie signée du présent formulaire de consentement.

Signature du responsable du projet ou son délégué(e) :

Date :

## QUESTIONNAIRES

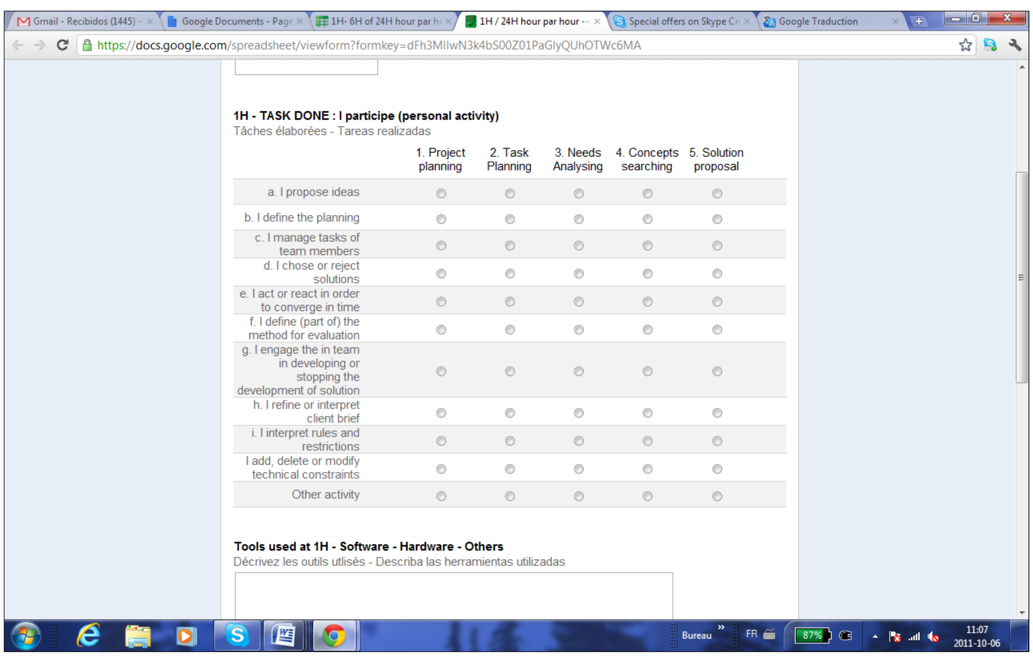
### Three hours-by-three hours - Multiple choice form: Activity and stage

| Activities \ Stage | | 1 Project Planning | 2 Task Planning | 3 Needs Analysis | 4 Concepts searching | 5 Solution proposal | 6 Dimension and measures | 7 Prototype | 8 Cost or economical analysis | 9 Presentation preparation | 10 Other activity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| a) | I propose solution ideas | | | | | | | | | | |
| b) | I define the planning | | | | | | | | | | |
| c) | I manage the task of team members | | | | | | | | | | |
| d) | I chose or reject solutions | | | | | | | | | | |
| e) | I act or react in order to converge in time | | | | | | | | | | |
| f) | I define (part of) the method for evaluation | | | | | | | | | | |
| g) | I engage the team in developing or stopping the development of a solution | | | | | | | | | | |
| h) | I refine or interpret the client brief | | | | | | | | | | |
| i) | I interpret rules and restrictions | | | | | | | | | | |
| j) | I add, delete or modify technical constraints | | | | | | | | | | |

Provide a more detailed description if you work in another activity that is not cited: (Open Question)

How many people work on this activity?

Possible screen visualization of Multiple Choice Form:



https://docs.google.com/spreadsheet/viewform?formkey=dFh3MllwN3k4bS00Z01PaGlyQUhOTWc6MA

**1H - TASK DONE : I participe (personal activity)**
Tâches élaborées - Tareas realizadas

| | 1. Project planning | 2. Task Planning | 3. Needs Analysing | 4. Concepts searching | 5. Solution proposal |
|---|---|---|---|---|---|
| a. I propose ideas | | | | | |
| b. I define the planning | | | | | |
| c. I manage tasks of team members | | | | | |
| d. I chose or reject solutions | | | | | |
| e. I act or react in order to converge in time | | | | | |
| f. I define (part of) the method for evaluation | | | | | |
| g. I engage the in team in developing or stopping the development of solution | | | | | |
| h. I refine or interpret client brief | | | | | |
| i. I interpret rules and restrictions | | | | | |
| I add, delete or modify technical constraints | | | | | |
| Other activity | | | | | |

**Tools used at 1H - Software - Hardware - Others**
Décrivez les outils utlisés - Describa las herramientas utilizadas

**Online forms:**

**Knowledge capture of context**

**1. Form 6H**

| **Item** | **Description** | |
|---|---|---|
| **Identification** | Code or e-mail:<br>Team name: | |
| **Activities realized** | Multiple choice (Frequent activities identified in Table 1) | |
| **Knowledge captured from the context** | What knowledge was essential to identifying the context of the project? (Open Question) | **Media used:**<br>a) Voice (Face-to-face)<br>b) Image<br>c) Drawing<br>d) Conceptual Map<br>e) Internet Link<br>f) Text<br>g) Video |
| | Who/Where do I find the information/ the knowledge to define the problem?<br>(Open Question) | **Information resources:**<br>a) People (consumers)<br>b) Internet search<br>c) Client (industrial constraints)<br>d) External expert<br>e) Internal team expert |
| | What tools/media do I use to express the context interpretation among team members?<br>(Open question) | Open question |
| **Needs** | Write the needs or expectations that you have at this design stage | I would like to work during this design stage with: |

| Item | Description | |
|---|---|---|
| | | (J'aimerais ou Je voudrais travailler avec) |
| **Tools used** | Multiple choice form | a) Paper – pencil<br>b) Board<br>c) Computer<br>d) Internet<br>e) Software:<br>f) Groupware:<br>g) Other (describe): |

**Knowledge Conceptual Stage**

**Form 15H**

| Item | Description | |
|---|---|---|
| **Identification** | Code or e-mail:<br>Team name: | |
| **Activities realized** | Multiple choice (Frequent activities identified in Table 1) | |
| **Conceptual stage** | How were the concepts of problem definition shared? | **Media used:**<br>a) Voice (Face-to-face)<br>b) Image<br>c) Drawing<br>d) Conceptual Map<br>e) Internet Link<br>f) Text<br>g) Video |
| | I would like to share my concepts through: | Open question |
| | How do you represent the key concepts? | **Media used:**<br>a) Voice (Face-to-face) |

| Item | Description | |
|---|---|---|
| | | b) Image<br>c) Drawing<br>d) Conceptual Map<br>e) Internet Link<br>f) Text<br>g) Video |
| | I would like to represent my concepts through: | Open Question |
| **Needs** | Write the needs or expectations that you have at this stage | I would like to work during this stage with:<br>(J'aimerais ou Je voudrais travailler avec) |
| **Tools used** | Multiple choice form | a) Paper – pencil<br>b) Board<br>c) Computer<br>d) Internet<br>e) Software:<br>f) Groupware:<br>g) Other (describe): |
| | I would like work with: | Open Question |

**Knowledge Codification – Presentation**

**Form 24H**

| Item | Description | |
|---|---|---|
| **Identification** | Code or e-mail:<br>Team name: | |
| **Activities realized** | Multiple choice (Frequent activities identified in Table 1) | |

| Item | Description | |
|---|---|---|
| **Methods** | How was the key concept that describes your product as an innovation defined? | Open Question |
| **Organization** | How was the concept to be identified as an innovation chosen? | Open Question |
| | How do you present the concept as an innovation? | Open Question |
| **Needs** | Write down the needs or expectations that you have at this stage | I would like to work during this stage with:<br>(J'aimerais ou Je voudrais travailler avec) |
| **Tools used** | Multiple choice form | a) Paper – pencil<br>b) Board<br>c) Computer<br>d) Internet<br>e) Software:<br>f) Groupware:<br>g) Other (describe): |
| | I would have liked to work with | Open Question |

Si vous avez utilisé des outils de créativité, est-ce que ces outils vous ont aidé dans votre projet? Expliquer en spécifiant le nom des outils utilisés – If you have used creativity tools, was this useful in your project? Explain, specifying the name of creativity tool used.

Avez-vous utilisé d'autres outils de créativité ou méthodes? – Did you use other creativity tools or methods?

**Continuation. Questionnaire d'information 0h**

**Projet de recherche :**

Analyse des activités et le support pour les équipes qui réalisent projets innovateurs lors de la compétition internationale 24 heures de l'innovation

**Questionnaire d'information**

Ce questionnaire vise à recueillir des informations sur vous, notamment votre formation, votre activité actuelle et vos expériences dans projets. Ces informations nous permettront identifier le profil des équipes participantes par rapport aux compétences et à l'expérience personnelle de ses membres.

**À propos de vous**

Âge __________ Sexe : Homme _________ Femme ________

**Votre formation**

Niveau d'études complétés Bac _________. DESS_____ Maîtrise_____ Doctorat _____

Discipline ____________

**Votre activité actuelle** (Ne remplissez que les champs qui s'adressent à votre situation)

Statut : Étudiant__________ Professeur__________ Professionnel __________

Domaine d'activité actuel

Programme d'études actuel : Bac_________ DESS _______ Maîtrise ____ Doctorat __

Discipline : ________________

**Vos expériences concernant le travail en équipe et en travail créatif**

Nombre d'outils informatiques utilisés pour les travaux en équipe :

Aucun ____1 à 5 _____ 6 à 10 _____ + de 10 _____________

Nombre de projets réalisés avec ces outils :

Aucun ____1 à 5 _____ 6 à 10 _____ + de 10 _____________

Nombre de participants dans les projets __________ Votre rôle : _____________

Activités réalisées :

_________________________________________________________________________

_________________________________________________________________________

Exemples de méthodes créatives ou d'outils utilisés :

_________________________________________________________________________

**Questionnaire sur la créativité**

Ce questionnaire vise à recueillir vos impressions sur vos activités créatives au cours de ces « 24h de l'innovation » ainsi que sur votre implication au sein de votre équipe de travail.

| **Évaluation de la composition du groupe** | | | | | | |
|---|---|---|---|---|---|---|
| | | **Rien** | **Un peu** | **Moy-enne** | **Un plus** | **Beaucou p** |
| **Évaluation personnelle** | | **1** | **2** | **3** | **4** | **5** |
| | | | | | | |
| 1 | Tolérance a l'ambiguïté | | | | | |
| 2 | Le problème est très complexe | | | | | |
| 3 | Possibilité de voir un problème selon diffé-rents points de vue | | | | | |
| 4 | Capable de générer beaucoup d'idées | | | | | |
| 5 | Extraverti plus qu'intraverti | | | | | |
| 6 | Capable de pensée en convergence et en di-vergence | | | | | |
| 7 | Capable de pensée en analytique et en intuitif | | | | | |
| 8 | Capable de produire des idées originales | | | | | |
| 9 | Contrôle du projet | | | | | |
| 10 | persévérance pour résoudre le problème | | | | | |
| 11 | confiance en soi | | | | | |
| 12 | prise de risques calculés | | | | | |
| 13 | Capable de produire une grande quantité idées | | | | | |
| 14 | Capable d'ajouter d'améliorer une idée exis-tante | | | | | |
| 15 | intérêts pour l'esthétisme | | | | | |
| 16 | Capable d'une pensée indépendante | | | | | |

| Évaluation de la composition du groupe | | | | | | |
|---|---|---|---|---|---|---|
| | | Rien | Un peu | Moyenne | Un plus | Beaucoup |
| | | **Non** | | | | **Oui** |
| | **Caractéristiques de groupe** | **1** | **2** | **3** | **4** | **5** |
| 1 | Même sexe | | | | | |
| 2 | Membres avec diverses personnalités | | | | | |
| 3 | Membres possèdent les mêmes habiletés créatives | | | | | |
| 4 | Compatibilité : besoins mutuels satisfaits | | | | | |
| 5 | Capables de travailler ensemble | | | | | |
| 6 | Moins de deux années d'expériences de travail | | | | | |
| 7 | J'ai pu convaincre aux autres de mes bonnes idées | | | | | |
| 8 | L'équipe a pris des risques dans le projet | | | | | |
| 9 | L'équipe a valorisé les idées ou les connaissances des co-équipiers | | | | | |
| 10 | J'ai pu suivre la démarche du projet | | | | | |
| 11 | J'ai compris clairement les idées de mes collègues | | | | | |
| 12 | J'étais impliqué dans l'obtention d'une innovation | | | | | |
| | | | | | | |

| **Caractéristiques du sujet demandé** | | **Rien** | **Un peu** | **Moyenne** | **Un plus** | **Beaucoup** |
|---|---|---|---|---|---|---|
| Le problème étudié a/est : | | 1 | 2 | 3 | 4 | 5 |
| 1 | relatif seulement à une solution | | | | | |
| 2 | très intéressant | | | | | |
| 3 | requiert un effort modéré pour obtenir une solution | | | | | |
| 4 | été travaillé par le groupe avant | | | | | |
| 5 | Requiert très peu de modélisation et calcul | | | | | |
| 6 | clairement compris pour tous | | | | | |
| 7 | fourni suffisamment d'informations | | | | | |
| 8 | a besoin de beaucoup de ressources pour résoudre | | | | | |
| | | **Rien** | **Un peu** | **Moyenne** | **Un plus** | **Beaucoup** |
| | | **1** | **2** | **3** | **4** | **5** |
| **La majorité du groupe** | | | | | | |
| 9 | a clairement compris la demande | | | | | |
| 10 | comprend les techniques créatives | | | | | |
| 11<br>12 | connaît son rôle au sein de l'équipe<br>fait les effort pour présenter des idées créatives | | | | | |

Pensez-vous qu'il manquait des ressources pour le travail créatif en équipe, qu'ils soient matériels ou logiciels ? Si tel est le cas, que proposeriez-vous ? :

Avez-vous de commentaires ou des suggestions additionnels ?:

**Évaluation Plateforme InnoKiz**

Les questions suivantes visent à recueillir des informations sur la façon dont les outils utilisés pendant l'expérience créative vous ont permis de réaliser de manière satisfaisant vos échanges d'idées avec la plateforme InnoKiz.

Échelle de qualification :

5 - Plutôt en accord

4 - Accord partiel

3 - Ni en accord, ni en désaccord

2- Désaccord partiel

1 - Plutôt en désaccord

| | **Metrics** | **Questions** Using InnoKiz … | **Score** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **5** | **4** | **3** | **2** | **1** |
| Q1 | Creativity performance | I easily express my ideas | 5 | 4 | 3 | 2 | 1 |
| Q2 | Usefulness | All my ideas were well expressed | 5 | 4 | 3 | 2 | 1 |
| Q3 | Team performance | I know the advances in my project | 5 | 4 | 3 | 2 | 1 |
| Q4 | Individual Creativity Performance | I understand and judge the ideas of my teammates | 5 | 4 | 3 | 2 | 1 |
| Q5 | Team performance | I observe changes made by my teammates | 5 | 4 | 3 | 2 | 1 |
| Q6 | Satisfaction | I would like to use this groupware in my next project | 5 | 4 | 3 | 2 | 1 |
| Q7 | Usefulness | It is easy to use this groupware | 5 | 4 | 3 | 2 | 1 |
| Q8 | Usefulness | All the functions, windows and menus are useful | 5 | 4 | 3 | 2 | 1 |
| Q9 | Performance | I visualize the recent activities of my teammates | 5 | 4 | 3 | 2 | 1 |
| Q10 | Performance | Groupware is not useful in the briefing of the project (preliminary stage) (* inverse score) | 5 | 4 | 3 | 2 | 1 |
| Q11 | Usefulness | Groupware is friendly | 5 | 4 | 3 | 2 | 1 |
| Q12 | Creativity performance | Groupware lets me be more creative | 5 | 4 | 3 | 2 | 1 |
| Q13 | Team performance | I could view responses and criticisms of my teammates | 5 | 4 | 3 | 2 | 1 |
| Q14 | Team performance | I know the direction that the project takes | 5 | 4 | 3 | 2 | 1 |
| Q15 | Accessibility | I could be connected with my social networking and other media (mobile telephone or Skype) | 5 | 4 | 3 | 2 | 1 |
| Q16 | Team performance | My team creativity was boosted (give advantage) with the use of this groupware | 5 | 4 | 3 | 2 | 1 |

2. For questions scoring 1 or 2, please give the reason. Feel free to explain the response. Thank you for writing the number of the question referenced:

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**GROUP INTERVIEW (After 24H)**

Open questions about knowledge needs in design stages

1. What knowledge was needed to "capture" the context?
2. How was the key concept of the product defined?
3. How was the knowledge produced about context interpretation presented?
4. How were the knowledge requirements of the context shared?
5. How was the key concept among teammates and stakeholders shared?
6. How was the key concept of the product presented?
7. What were key concepts that defined the innovation of your product?
8. How was the product chosen as the most innovative concept?
9. How the concept to be identified as innovative was presented?

## APPENDIX II

## CREATIVE TEAMS OF 24H INNOVATION, MAY 2012

Participants at 5th Edition 24H of Innovation at May 2012

| Team # | Code | Name | | Participants | eRoom | Location | Site |
|---|---|---|---|---|---|---|---|
| 1 | 2 | Pucarã¡ | 89 | 2 | | Local | UNS |
| 2 | 3 | Jetak | 36 | 22 | | Local | ESIROI |
| 3 | 4 | Global Montreal Teamkiz! | 89 | 1 | | Virtual | Innokiz |
| 4 | 5 | Les Avengers | 70 | 5 | | Local | UTBM |
| 5 | 6 | Les Marcan's | 70 | 4 | | Local | UTBM |
| 6 | 7 | La Meute | 36 | 5 | | Local | ESIROI |
| 7 | 8 | Marmex | 35 | 7 | | Local | UTBM |
| 8 | 10 | Tarteamflette | 87 | 1 | | Local | UTBM |
| 9 | 11 | Patrick's Team | 54 | 6 | | Local | UTBM |
| 10 | 12 | Re'ActISEN | 40 | 1 | | Local | Antel |
| 11 | 13 | Re'Act ISEN | 40 | 5 | | Local | ISEN |
| 12 | 14 | Crafteam | 87 | 6 | | Local | UTBM |
| 13 | 15 | Codecharrette | 87 | 3 | | Local | ESIROI |
| 14 | 16 | Fiqrateam | 79 | 3 | | Local | UTBM |
| 15 | 17 | Fraich' Design | 54 | 6 | | Local | UTBM |
| 16 | 18 | Limitless | 55 | 68 | | Local | UMBB |
| 17 | 19 | Ieteam | 69 | 10 | | Local | UTBM |
| 18 | 20 | Black Hammer | 64 | 7 | | Local | UTBM |
| 19 | 21 | Buildtodream | 75 | 0 | | Local | Antel |
| 20 | 22 | Impro Team | 54 | 4 | | Local | UTBM |
| 21 | 23 | Cod'innov | 87 | 2 | | Local | ESIROI |
| 22 | 24 | Wall | 40 | 1 | | Local | ISEN |
| 23 | 25 | Innocode 6 | 63 | 2 | | Local | ESIROI |
| 24 | 27 | Mapple Lys Team | 75 | 4 | | Local | UTC |
| 25 | 28 | Les SIX FANTASTIQUES | 69 | 0 | | Local | UTBM |
| 26 | 29 | Le Groupe Brise | 89 | 1 | | Virtual | Innokiz |
| 27 | 31 | Igtp | 92 | 6 | | Virtual | Innokiz |
| 28 | 32 | Wall Interact | 40 | 6 | | Local | ISEN |
| 29 | 33 | Electronutnba_Team | 55 | 100 | | Local | UTN |
| 30 | 34 | Utcleaners | 54 | 6 | | Local | ÉTS |

| Team # | Code | Name | | Participants | eRoom | Location | Site |
|---|---|---|---|---|---|---|---|
| 31 | 35 | A-Mixolidio | 40 | 2 | | Local | Antel |
| 32 | 36 | Jack Daniel's | 71 | 5 | | Local | UTBM |
| 33 | 37 | Unmdp Bis | 57 | 12 | | Virtual | Innokiz |
| 34 | 38 | Escape | 63 | 2 | | Local | ESIROI |
| 35 | 39 | Les MéCaniciens De L'extrãªme | 71 | 6 | | Local | UTBM |
| 36 | 40 | Les Renihilistes | 64 | 4 | | Local | UTBM |
| 37 | 41 | Eco-Transformers | 36 | 10 | | Local | UTT |
| 38 | 42 | 6-Freddy | 66 | 4 | | Local | UTBM |
| 39 | 43 | Re-Volt | 55 | 20 | | Local | UMBB |
| 40 | 44 | K'isen Cool | 71 | 7 | | Local | ISEN |
| 41 | 45 | Los Electrã³Nicos | 71 | 8 | | Local | UNS |
| 42 | 46 | Inelmadhen | 39 | 3 | | Local | UMBB |
| 43 | 47 | Commutt | 69 | 11 | | Local | UTT |
| 44 | 48 | Tar'teamflette | 66 | 2 | | Local | UTBM |
| 45 | 49 | Good Old Team | 54 | 1 | | Local | UTC |
| 46 | 50 | 6-Rocco | 64 | 1 | | Local | UTBM |
| 47 | 51 | Geek Inside | 66 | 5 | | Local | UTBM |
| 48 | 52 | Est'I.A. | 73 | 117 | | Local | ESTIA |
| 49 | 53 | Piou-Piou | 54 | 9 | | Local | UTC |
| 50 | 54 | Unmdp | 66 | 7 | | Virtual | Innokiz |
| 51 | 55 | Ingenergã A | 71 | 2 | | Local | UTN |
| 52 | 56 | Eureka | 54 | 4 | | Local | Antel |
| 53 | 57 | Pedrotv | 92 | 0 | | Virtual | Innokiz |
| 54 | 58 | Bodynnovation | 71 | 3 | | Local | ISEN |
| 55 | 59 | Coming Death | 73 | 9 | | Local | UMBB |
| 56 | 60 | Henergy | 71 | 7 | | Local | UTN |
| 57 | 61 | Biotech | 71 | 89 | | Local | Antel |
| 58 | 62 | Isenovation | 79 | 9 | | Local | ISEN |
| 59 | 63 | The A-Team | 65 | 3 | | Local | ISEN |
| 60 | 64 | Robotina | 54 | 2 | | Local | Antel |
| 61 | 65 | L'innovation C'est Maintenant | 40 | 24 | | Local | UTC |
| 62 | 66 | Los Cualquiera | 40 | 2 | | Virtual | Innokiz |
| 63 | 67 | Six-Rocco | 50 | 2 | | Local | UTBM |
| 64 | 68 | Unoso | 69 | 14 | | Local | UTN |
| 65 | 69 | Bioeconotronicodis | 70 | 3 | Yes | Local | UNS |
| 66 | 70 | La Gansta Team | 40 | 7 | | Local | ÉTS |
| 67 | 71 | #Mur | 40 | 13 | | Local | Antel |
| 68 | 72 | Time Out | 87 | 12 | | Local | UTC |

| Team # | Code | Name | | Participants | eRoom | Location | Site |
|---|---|---|---|---|---|---|---|
| 69 | 73 | Rãªve Chasseur | 63 | 6 | | Local | UTSEUS |
| 70 | 74 | Eclipse | 66 | 3 | | Local | ÉTS |
| 71 | 75 | FCOM Y Juan | 40 | 29 | | Local | Antel |
| 72 | 76 | Iiiiiiii | 66 | 41 | | Local | UTC |
| 73 | 77 | Duam | 36 | 6 | | Local | UCTemuco |
| 74 | 78 | Unitã© De Trouvation Crã©Ativesque | 87 | 11 | | Local | UTC |
| 75 | 79 | Go 2.0 | 69 | 3 | | Local | UNS |
| 76 | 80 | Brainstormers | 58 | 0 | | Local | UNS |
| 77 | 81 | Iftic-Sup Genius | 65 | 4 | Yes | Local | IFTIC-SUP |
| 78 | 82 | The Brainstormers | 58 | 10 | | Local | UNS |
| 79 | 83 | Cameleon | 40 | 1 | Yes | Virtual | Innokiz |
| 80 | 84 | Lgge | 79 | 8 | | Local | Antel |
| 81 | 85 | Viento En Contra | 64 | 1 | | Local | UNS |
| 82 | 86 | Adquadratum | 69 | 3 | | Local | Antel |
| 83 | 87 | Logic Gates | 55 | 29 | | Local | UMBB |
| 84 | 88 | Legendarium | 40 | 4 | | Local | ENIT |
| 85 | 89 | Deag | 63 | 3 | | Local | UNS |
| 86 | 90 | 10 It | 71 | 6 | | Local | UNS |
| 87 | 91 | Idunno | 65 | 2 | | Local | UMBB |
| 88 | 92 | Savoir + | 32 | 0 | | Local | Antel |
| 89 | 94 | Locomotiv | 71 | 7 | | Local | UNS |
| 90 | 95 | Amancay | 40 | 5 | | Local | UNS |
| 91 | 96 | Nvaf | 71 | 8 | | Local | UNS |
| 92 | 97 | Sigma | 58 | 8 | | Local | UTC |
| 93 | 99 | Oui | 65 | 2 | | Local | CDandI Associ-ates |
| 94 | 100 | Limitless People | 58 | 0 | | Virtual | Innokiz |
| 95 | 101 | Agi | 69 | 6 | | Local | UTC |
| 96 | 102 | Craf'team | 66 | 1 | | Local | Antel |
| 97 | 103 | A Tiempo | 71 | 4 | | Virtual | Innokiz |
| 98 | 104 | Afkentu | 55 | 24 | | Local | UNS |
| 99 | 105 | Frenchbulls | 54 | 0 | | Local | UTBM |
| 100 | 106 | Blancanieves y Los 9 Ingenieros | 69 | 4 | | Local | Antel |
| 101 | 107 | Grey Substance | 57 | 7 | | Local | UMBB |
| 102 | 108 | Brainstormichel | 70 | 3 | | Local | UTC |
| 103 | 109 | Refistro | 35 | 0 | | Local | Antel |
| 104 | 110 | Diboco | 66 | 4 | | Local | CDandI Associ-ates |
| 105 | 111 | Zaedyus Innovatis | 79 | 2 | | Local | UNS |

| Team # | Code | Name | | Participants | eRoom | Location | Site |
|---|---|---|---|---|---|---|---|
| 106 | 112 | Cdo | 64 | 5 | | Virtual | Innokiz |
| 107 | 113 | Innovplus | 58 | 6 | | Local | IFTIC-SUP |
| 108 | 114 | Entrepenuy | 55 | 35 | | Local | Antel |
| 109 | 115 | 16 Uruguay | 55 | 28 | | Local | Antel |
| 110 | 116 | Djurdjura | 55 | 3 | | Local | UMBB |
| 111 | 117 | Savoir Plus | 57 | 4 | | Virtual | Innokiz |
| 112 | 118 | Winnerworld | 71 | 8 | | Local | UTC |
| 113 | 119 | Inc | 55 | 1 | | Local | UTSEUS |
| 114 | 120 | Iftic-Forza | 92 | 5 | | Local | IFTIC-SUP |
| 115 | 121 | Cambio De Paradigma | 92 | 0 | | Local | UNS |
| 116 | 122 | On Time | 69 | 3 | | Local | UNS |
| 117 | 123 | Belsterli | 73 | 0 | | Local | Antel |
| 118 | 124 | Idunno2 | 54 | 2 | | Local | UMBB |
| 119 | 125 | Cd&I | 64 | 1 | | Local | INNOKIZ |
| 120 | 126 | I.D.I | 64 | 4 | | Local | CDandI Associates |
| 121 | 127 | Los cualquiera | 40 | 0 | | Local | CDandI Associates |
| 122 | 128 | G2foss | 65 | 7 | | Local | ENIT |
| 123 | 129 | Brainstormichel1 | 70 | 0 | | Local | UTC |
| 124 | 130 | Sensibilitã© | 53 | 3 | | Local | UTSEUS |
| 125 | 131 | Le Groupe Brise2 | 53 | 1 | | Local | UNS |
| 126 | 132 | Bouloulou | 32 | 0 | | Local | Antel |
| 127 | 134 | C.D.S. | 67 | 4 | | Local | ÉTS |
| 128 | 136 | Ee | 71 | 5 | | Local | Antel |
| 129 | 138 | Iqtep.Uy | 54 | 19 | | Local | Antel |
| 130 | 146 | Gastã³N | 54 | 1 | | Local | Antel |
| 131 | 141 | Go Go | 32 | 0 | | Local | UMBB |
| 132 | 142 | Arnab | 32 | 0 | | Local | ZIG |
| 133 | 144 | Intelagency | 73 | 4 | | Local | UTSEUS |
| 134 | 145 | Innuy | 72 | 3 | | Local | Antel |
| 135 | 149 | Prix | 57 | 0 | | Local | Antel |

## APPENDIX III

## QUALITATIVE DATA ABOUT INNOKIZ EVALUATION

This appendix presents the data obtained following low scores for some InnoKiz functionalities. 40 participants responded.

QUALITATIVE ANALYSIS. Table 1

| Participant | Please, describe why did you rate low 1 or 2 the last questions (about InnoKiz use/satisfaction) | Categories about low functionnalities rating | Why use InnoKiz ? Which functionnalities did you use? |
|---|---|---|---|
| P1 | non | | non |
| P2 | 1. No usé la plataforma para la comunicación dado que estuvimos siempre en el mismo sitio. | Non use of InnoKiz, I am in a Colocalised team | Para comunicarme con el administrador y controlar el proyecto |
| P3 | Le site n'est pas assez érgonomique ..... on doit se familiariser plus avec le site. | Low human factors | web conférence. |
| P4 | no escogi uno ni dos | Unfamiliarity | no lo utilice |
| P5 | porque no necesitamos usarla, sentimos que perdíamos mas tiempo usándola | Non necessary the utilisation | la usamos muy poco |
| P6 | No se entiende la pregunta. | Lost of time using a platform for a colocalised team | Para subir las ideas. |
| P7 | hubo buenos recursos humanos en el grupo. todos escuchamos las ideas y las criticas de todos | Good communication with the team | para compartir tareas y opinar de su viabilidad y elegir la optima. Permite calificar al proyecto según diferentes competencias (ecológicas, económicas, etc.) |
| P8 | Innokiz est une plateforme collaborative d'echange de connaissances et de création en terme d'innovation | | pour la recherche de la créativité en terme d'innovation |
| P9 | la herramienta tiene sus limitaciones. y el relleno de tantos formularios complica el trabajo | Limitations of the information exchanged | para contactarse con todo el equipo |
| P10 | el sistemael formulario a veces es poco cprensible (sobre todo los cuadros de doble entrada) y además es excesivamente burocrático y va en contra d ela creatividad del grupo. | Not necessary complete information | ideas, mails, contactos.. informes del resto, noticias de la organización |
| P11 | me sentí muy cómoda con el grupo, lo que permitio que me exprese libremente | Not interesting see guide | para mantenerme en contacto en la red con mis compañeros del equipo |
| P12 | todo el equipo estuvo reunido en un solo sitio y no fue necesario usar herramientas de teamwork | Colocalised team | para conocer los mensajes y completar los formularios |
| P13 | No volvería a usar esta plataforma, ya que existen otras que permiten incorporar la misma información, y q son de uso diario. | It is not easy incorporate information | La usamos únicamente para subir la idea final, porque creimos que era obligatorio. |
| P14 | Dfurust | Other platform more easy and on basic diary use(Dropbox) | solo para informarme de algunas cosas |
| P15 | no las seleccione | | no se como se utiliza |
| P16 | es poco práctica la herramienta, en eficiciencia de tiempos | Not efficient | información sobre el evento |
| P17 | no puse ningun 1 o 2 | | para saber el avance del equipo y como iban el resto de los equipos |
| P18 | N/N | | para poder hacer un auto seguimiento, y reportar el progreso del equipo. |
| P19 | no eleji ninguna | | no lo utilice |
| P20 | - | | pas utilisé |

| QUALITATIVE ANALYSIS. Table 1 (Continuation) | | | |
|---|---|---|---|
| Participant | Please, describe why did you rate low 1 or 2 the last questions (about InnoKiz use/satisfaction) | Categories about low functionnalities rating | Why use InnoKiz ? Which functionnalities did you use? |
| P21 | L'outil Innokiz ne me semble pas assez intuitif et trop confus par endroits. | Not intuitive and complicate | Pratique pour le partage d'informations et l'accès à différentes ressources (sujets, autres équipes, ...) |
| P22 | Travaillant ensemble, il est plus simple d'exprimer les idées de vive voie | Colocalised team | Pour le travail a distance |
| P23 | no eleji ninguna | | no utilice innokiz |
| P24 | no eleji ninguna | | no lo utilice |
| P25 | - | | We work mostrly with teamkiz and help/resources. |
| P26 | no | | para conectarme con mi equipo |
| P27 | xhd | | contacto con el grupo |
| P28 | dfurust | | dfhdsgh |
| P29 | no | | todas |
| P30 | * | It lacks of a system of file sharing (Dropbox) or Tchat for brainstorming | * |
| P31 | Se trabajó en un ambiente amable  y todos se epresaron libremente | Local environment pleaseful | mensajería y control de avance del trabajo |
| P32 | 1 - Le système est rigide et peu réactif, un système de partage de fichier comme dropbox ou encore un service de tchat pour faciliter le brainstorming.<br>2 - L'outil de présentation d'idée est ultra complet voire même un peu trop. Une idée est par définition quelque chose d'abstrait qui doit permettre de développer la créativité de mes camarades. le caractère obligatoire de certains champs dans un contexte de brainstorming est rébarbatif. | The system is rigid. Low response reaction. It lacks of a file sharing system like Dropbox. It lacks a chat service to facilitate brainstorming.<br>2 - The  idea presentation tool is very complete (even a little too much). One idea is by definition something abstract which should help develop the creativity of my friends. the mandatory nature of certain fields in the context of brainstorming is daunting. | Parce que c'etait l'unique moyen de travailler en adéquation avec le concours. |
| P33 | Un poco complicada de manejar. | Difficult to use | No la usé realmente |
| P34 | - | | Nous avons été informé de l'existence de ce site au dernier moment, on s'en est pas beaucoup servis au final ...<br><br>Manque de communication ... |
| P35 | exprese facilmente mis ideas y pudimos trabajar muy bien en grupo | Colocalised team | con todas |
| P36 | Pour la majorité des questions, interface peu claire, difficulté à comprendre dans quelle section se rendre pour telle ou telle information | Complicated interface. Difficult to brownse inside the Platform. Difficult to distinguish fonctionnalities. Difficult to update information | Je n'ai pas du tout utilisé Innokiz |
| P37 | Si bien teoricamente me encanta la herramienta y el hecho de poder estar en contacto con un interés común sin distracciones extras encuentro que me fue muy difícil la navegación dentro del sitio y que los updates no eran sencillos. | Difficult to use. Difficult to update information. Low response reaction. Difficult to brownse | Para gestionar y ordenar proyectos; presenciales o remotos. No pude usar muchas funcionalidades. |
| P38 | - | | Lo utilizamos poco en el grupo. |
| P39 | - | | planning |
| P40 | On ne nous a pas bien expliqué les fonctionnalités de Innokiz. | Lack of information and explaination about the Platform | L'avancement du projet. |

| QUALITATIVE ANALYSIS. Table 1 (Continuation) | | | |
|---|---|---|---|
| **Participant** | **Categories about Why use InnoKiz?** | **Do you think that it lacks of tools to creative teamwork? Software or materials? What do you propose?** | **Categories to add resources for collaborate** |
| **P1** | | non | |
| **P2** | **Administration Board** | | |
| **P3** | **Project control** | Un contacte audio visuel avec les propriétaires de projets.<br>Une description encore plus détaillé des limites de nos innovations. | **Audio-visual contact with Project owners** |
| **P4** | **WebConference** | | |
| **P5** | **Ideas Sharing** | creo que no | |
| **P6** | **Ideas Selection** | No falta nada. | |
| **P7** | **Project qualification** | | |
| **P8** | **Research in Creativity and Innovation** | oui!!!<br>dans notre cas il faut :<br><br>-- Connection internet très haut débit<br>-- materiel de conception<br>-- expertise metier<br>-- ajout d'un module de messagerie instantanée sur Innokiz entre les membres d'une équipe ou d'un pays | **Internet High Velocity, Material for design, Expertise in the domain, Agregates an instant messages to InnoKiz among team et among world participants** |
| **P9** | **To be connected with the team** | no | |
| **P10** | **Ideas, mails, contacts and new of the organisation** | si. faltan anteriormente lo expresé | |
| **P11** | **Contact with my teammates** | no | |
| **P12** | **Knowing messages and guides** | la experiencia no permite opinar. | |
| **P13** | **Display result (a part of competition)** | Estuvo muy mal organizado el manejo de interne. En el lugar central de trabajo, internet andaba con una velocidad muy baja e incluso llegó a cortarse. Hubo grandes problemas de información a lo largo de toda la competencia. | **Internet Problems, Organization of information for the Competence** |
| **P14** | | creo q no. | |
| **P15** | | | |
| **P16** | **Events information** | quiza. | |
| **P17** | **Knowing teamwork changes and advancing** | no creo q falte nada | |
| **P18** | **Following others teams** | No. Tuvimos todo a lo que necesitamos a nuestro alcance. | **Time** |
| **P19** | | | |
| **P20** | | - | |

| QUALITATIVE ANALYSIS. Table 1 (Continuation) | | | |
|---|---|---|---|
| Participant | Categories about Why use InnoKiz? | Do you think that it lacks of tools to creative teamwork? Software or materials? What do you propose? | Categories to add resources for collaborate |
| P21 | Information sharing and acces to others ressources | Connaissances générales en design, veille technologique. | Knowledge Technology Watch |
| P22 | Distance work | des noms plus explicite que des "iz" partout | The names IZ more explicit |
| P23 | | | |
| P24 | | | |
| P25 | TeamKiz and help/ressources | | |
| P26 | To be connected with the team | | |
| P27 | To be connected with the team | | |
| P28 | | fdfhdhs | |
| P29 | | | |
| P30 | Knowing teamwork changes and advancing | * | |
| P31 | Messages | esta bien así | |
| P32 | Display result (a part of competition) | Oui : Un service de tchat, un service de partage de fichier voire même un espace collaboratif. Ou du moins la proposition de service d'appui pour la téléconférence. | Chat services, File sharing system in the espace collaborative |
| P33 | | El material está. | Teleconference |
| P34 | Lacks of communication | - | |
| P35 | All fonctionnalities | | |
| P36 | | Pour moi le site devrait être plus clair et simplement contenir les résultats des équipes | Simplicity, only results |
| P37 | Project Management | Modos sencillos de hacer mapas semánticos. | Modes to do semantic maps |
| P38 | Planning | Falta describir con mas detalle el objetivo a plantear. | More description of objectives |
| P39 | | non | |
| P40 | Knowing teamwork changes and advancing | | |

| ANALYSIS QUALITATIVE. Table 1 (continuation) | | | |
|---|---|---|---|
| **Participant** | **Did you have used a creativity process, was it useful in your project ?** | **If you have used a creativity process, was it useful in your project ? Explain** | **Creative Process Methods** |
| **P1** | **Yes** | non | |
| **P2** | **Non** | | |
| **P3** | **Yes** | on a définit un protocole a suivre pour trouver une sollution selon le besoin donc l'objectif du projet. après pour la selection des idée proposé par les subteam, on juge les idées selon le tableau de critères des jury. | **Protocol to find solution, evaluation according with Jury criteria** |
| **P4** | **Yes** | | |
| **P5** | **Yes** | si, para sacar provecho al problema propuesto | **Problem Analysis** |
| **P6** | **Yes** | Fue de Ayuda | |
| **P7** | **Yes** | | |
| **P8** | **Yes** | oui !!!<br><br>-- recherche approfondie sur le problème que dégage notre projet<br>-- listing des idées ou solutions proposées par chaque membre de l'équipe!!<br>-- grande évaluation de ces idées pour retenir celles qui vont dans le même objectif de notre projet<br>-- répartition des taches | **Problem Analysis, Research, Listing ideas by individual, Task Distribution,** |
| **P9** | **Yes** | trabajar en equipo ayudo a ver las limitaciones de las ideas de cada uno | **Teamwork for Ideas Analysing** |
| **P10** | **Yes** | si, nuestra organización personal por tareas y áreas .nos ayudó a ir a tiempo | **Individual Task** |
| **P11** | **Yes** | si, creamos una maqueta totalmente armada a mano | **Modeling** |
| **P12** | **Yes** | el equipo estuvo presencialmente reunido en forma permanente por lo que la herramienta de creatividad empleada fue la pizarra, el intercambio de opiniones y brainstorming. | **Brainstorming** |
| **P13** | **Non** | | |
| **P14** | **Non** | | |
| **P15** | **Yes** | | |
| **P16** | **Yes** | brainstorming | **Brainstorming** |
| **P17** | **Yes** | utilizamos procesos propios como la realizacion de la maqueta | **Modeling** |
| **P18** | **Non** | | |
| **P19** | **Yes** | | |
| **P20** | **Yes** | trouver de nouvelles idées, structure le projet | **Ideas Analysing, Project Structuring** |

| ANALYSIS QUALITATIVE. Table 1 (continuation) | | | |
|---|---|---|---|
| **Participant** | **Did you have used a creativity process, was it useful in your project ?** | **If you have used a creativity process, was it useful in your project ? Explain** | **Creative Process Methods** |
| **P21** | **Yes** | | |
| **P22** | **Non** | | |
| **P23** | **Yes** | | |
| **P24** | **Yes** | | |
| **P25** | **Yes** | | |
| **P26** | **Yes** | | |
| **P27** | **Yes** | no | |
| **P28** | **Yes** | dfzhdysd | |
| **P29** | **Yes** | | |
| **P30** | **Non** | | |
| **P31** | **Yes** | La solución más simple es la correcta | **Seaching simplicity in the solution** |
| **P32** | **Yes** | Le travail était surtout ponctué par des pic de créativité et de productivité. | **Criteria Definition for Creativity and Productivity** |
| **P33** | **Yes** | | |
| **P34** | **Yes** | - | |
| **P35** | **Yes** | | |
| **P36** | **Non** | | |
| **P37** | **Yes** | | |
| **P38** | **Yes** | Si fue de ayuda para el proyecto elejido. | |
| **P39** | **Non** | | |
| **P40** | **Non** | | |

| ANALYSIS QUALITATIVE. Table 1 (continuation) | | | | |
|---|---|---|---|---|
| Participant | Explain specifying the name of creativity tool used | Name of Creative Method | What kind of obstacles did you have to collaborate? Explain | Obstacles collaboration |
| P1 | non | | je saia pas | |
| P2 | | | | |
| P3 | Organisation<br>Imagination<br>Ecriture de toute idée ou pensé dans l'axe de la solution. | **Organisation, Imagination, Writing of all ideas** | Les petites querelles pour imposer nos avis.<br>le stresse liée au temps.<br>la fatigue.<br>le silence.<br>En plus de ça je trouve que l'outil informatique doit etre perfectionner. car pour l'instant rien ne remplace le stylo et le cahier ainsi que le tableau. | **Personal conflicts to impose ideas. Stress for time. Fatigue. Informatics tools non improved. Workbook and pencil, tablet** |
| P4 | | | | |
| P5 | si, utilizamos brainstorming | **Brainstorming** | no hubo obstáculos | |
| P6 | Fueron Utiles | | | |
| P7 | | | | |
| P8 | oui !!!<br>-- organisation au niveaux des idées !!!<br>-- travail ordonné!!<br>-- evaluation du projet<br>-- evaluation financière et économique du projet<br>-- avantages du projet<br>-- limites du projet | **Ideas Organisation, Orderly Work, Project Evaluation, Financial Project Evaluation, Project Limitations** | -- choix des idées !!!<br>-- choix des solutions !!<br>--confection du noyau de notre projet!! | **Ideas, Solutions Selection. Searching for the project core** |
| P9 | nos ayudo a coordinar rapidamente debido a la limitacion de tiempo | **Quickly coordination to manage time** | el sueño | **Sleepless** |
| P10 | si por lo expresado, eficiencia de tiempos y no colgar. | **Quickly coordination to manage time** | el sueño. | **Sleepless** |
| P11 | muy util, pudimos representar nuestro proyecto | **Project Representation** | | |
| P12 | ninguna informatica debido a las condiciones relatadas. | | | |
| P13 | | | | |
| P14 | | | | |
| P15 | | | | |
| P16 | si, todo participabamos activiamente brindadndo ideas al equipo | | el sueño<br>las diferencias en los campos de trabajo | **Sleepless, Domaine work differences** |
| P17 | si fueron utiles ya que nos permitieron crear de manera mas real el prototipo | | ninuguna | |
| P18 | | | N/N | |
| P19 | | | | |
| P20 | oui, un peu<br>analyse de la valeur<br>brainstorming | | le manque de connaissance des competences respectives | **lack of knowledge of the respective competences** |

| ANALYSIS QUALITATIVE. Table 1 (continuation) | | | | |
|---|---|---|---|---|
| **Participant** | **Explain specifying the name of creativity tool used** | **Name of Creative Method** | **What kind of obstacles did you have to collaborate? Explain** | **Obstacles collaboration** |
| **P21** | | | | |
| **P22** | | | La fatigue | **Fatigue** |
| **P23** | | | | |
| **P24** | | | | |
| **P25** | | | | |
| **P26** | | | | |
| **P27** | corel | | | |
| **P28** | dsghgjxd | | | |
| **P29** | | | | |
| **P30** | | | * | |
| **P31** | | | | |
| **P32** | Non, c'est le démon de la deadline qui a fait tout le boulot ^^ | | | |
| **P33** | | | | |
| **P34** | - | | création de l'équipe 5 minutes avant le début de la compétition ... alors que les autres équipe connaissaient leurs coéquipiers. | **Team without preparation** |
| **P35** | | | | |
| **P36** | | | Fatigue, équipe trop grande (10 personnes) | **Fatigue. Large team about 10 participants** |
| **P37** | | | | |
| **P38** | Si fueron muy utiles. | | si | |
| **P39** | | | aucun | |
| **P40** | | | | |

## APPENDIX IV

## UML 2 GLOSSARY

- *Activity diagram* "shows a sequential flow of actions. The activity diagram is typically used to describe the activities performed in a general process workflow, though it can also be used to describe other activity flows, such as a use case or a detailed control flow" (p.28).
- *Architecture:* as cited by Eriksson *et al.* (2004): "The architecture works as a map of the system that defines the different parts of the system, their relationships and interactions, their communication mechanisms, and the overall rules for how parts may be added or changed" (Eriksson et al., 2004, p. 361).
- *Class diagram* shows a static structure, it describes architecture, focusing on the structure of the system divided into "packages, components, and their dependencies and interfaces" (Eriksson et al., 2004, p. 254). A class is distinguished because it defines a series of activities that have to be structured and organized to put in place all system interactions. Also, a class is an entity that defines the task to be achieved in the system, and sometimes could describe "members that are attributes, operations, and relationships to other classes" (Eriksson et al., 2004, p. 463).
- *Classes* represent the "things" that are handled in the system. "A class diagram shows the static structure of classes in the system. [And] Classes can be related to each other" (p. 25).
- *Composite structure diagrams* "show parts and connectors [...]. Parts are shown in a similar manner as an object, but the name is not underlined. The diagram specifies the structural features that will be required to support the enclosing classifier" (Eriksson et al., 2004, p. 258). Composite structure diagrams explain the logical architecture, which for its part gives a "clear understanding of the construction of the system to make it easier to administer and coordinate the work" (Eriksson et al., 2004, p. 254). There are two diagrams that explain the architecture of a system: the class diagram and the logical architecture structure.
- *Interaction diagrams "*provide a number of diagrams that show the interaction between objects during the execution of the software. These diagrams include sequence diagrams, which emphasize modeling the potential ordering options of an interaction; communication

diagrams, which look at the structures of the interacting objects; and interaction overview diagrams, which place interaction fragments, or fragments of sequence diagrams, in a high-level workflow" (p. 29);

- *Sequence diagrams:* "illustrate how objects interact with each other. They focus on message sequences, that is, how messages are sent and received between a number of objects" (Eriksson et al., 2004, p. 174).

- *A State machine* "is typically a complement to the description of a class. It shows all the possible states that objects of the class can have during a life-cycle instance, and which events cause the state to change. An event can be triggered by another object that sends a message to it—for example, that a specified time has elapsed—or that some condition has been fulfilled. A change of state is called a *transition*. A transition can also have some sort of behaviour connected to it that specifies what is done in connection with the state transition". (p.26);

- *Use case View* is a formal model that shows the systems to external actors (Charroux et al, p.35). "The use case view is used by customers, designers, developers, and testers; it is described in use case diagrams, sometimes with support from activity diagrams" (Eriksson et al., 2004, p. 22), the use case view has to be explained by the follow diagrams:

- *Use cases* "help to focus mounds of technical information on tangible value" (Eriksson et al., 2004, p. 57) for the user. Also, use case diagrams "show concisely and efficiently, even with stick figures and circles, what a system can provide" (idem). The use cases describe how the system is composed of subsystems.

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