Exploring designers behavior in collaborative design meetings

- A graphic approach

Pablo Garrido
EXPLORING DESIGNERS BEHAVIOR IN COLLABORATIVE DESIGN MEETINGS: A GRAPHIC APPROACH

By Pablo Garrido
ABSTRACT

Globalization has caused international companies to spread over countries and continents. Moreover, product development has new and more demanding challenges, like Functional Products, conceived to cover full user’s requirements by offering functions, instead of features. This situation has caused collaboration to become tighter between engineers, often adding team members from different disciplines, and also geographically distributed.

The aim of tele-collaboration research is to permit an effective interaction between designers, which conform nowadays needs. Some technological innovation seeks to approach distributed communication to a co-located level. However, imitation will never substitute the real thing, and, and by this principle, these technologies will never fully achieve this goal. Instead, research should look for new forms of interaction, better than the ones that occur in co-located meetings.

Most of the work done in this thesis arises from the believing that to achieve a new, truly efficient technology, further exploration on designers’ collaboration behavior must be done. Only by understanding they real needs we will be able to fully satisfy them. That’s why a ‘new’ study method is suggested, based on previous theoretical and practical work. This method consists on describing designers’ interaction by 5 senses, namely sense of presence, sense of time, sense of space, sense of sharing, and sense of naturalness.

Specifically, this senses are applied on the analysis of creative design meetings, which conformed one of the first phases of product development. In these meetings, interaction within designers is pretty tight. Participants usually have different backgrounds and different approaches to the problem, and it is common the use of design objects, like sketches, prototypes, or any kind of document.

The aim of this method is permitting us to better understand the interaction requirements in these kinds of meetings, where different creativity techniques are used, in order to find out which tele-collaboration technologies would be more suitable to perform them. The graphic nature of the method allows performing a rapid, intuitive match between techniques and technologies. The discussion of the ‘coupling’ between them may give us valuable input for future research.
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1. INTRODUCTION

In the recent years, the way in which Product Development is being made has changed. It is no longer performed in just a single company, but rather in cross-company and cross-disciplinary teams. These teams should work together towards a common set of consistent goals, supported by an integrated computer environment where the information is shared between teams, machines and processes (Prasad, 1996).

This need of distributed teamwork has been increased by the recent apparition of a new industrial demand, the so-called “Functional Products”, which are products capable of being sold as functions in addition to the parts of which they constitute. According to Brännström, a Functional Product (FP) “combines the lifecycle processes of hardware, software and services” (Brännström). The effect of expanding this product definition implies an increased and stronger collaboration between engineering departments and departments with whom they have had no normal communication with in previous non-FP projects (Peter Törlind, 2005). Consequently, not only the task of inventing and designing a breakthrough product is challenging but also the interaction and communication within that team (Bergström, 2009).

Specifically, in the early phases of product development collaboration needs to be especially tighter between designers. That is the case of creative design meetings, where design specifications are not yet established, and new concepts and ideas can arise. In these sessions, designers may need to interact in many different ways, trying to achieve a common understanding of the problem, as well as applying their knowledge and skills to solve it.

Research in tele-collaboration technologies must be headed to find ways to afford these distributed collaboration needs, while emphasizing creativity.

1.1. Research goals

In order to determine the features of tele-collaboration technologies, as in any product development process (Karl T. Ulrich, 1995), it is paramount to find out which are the real needs of this collaboration. However, a team of designers may need to interact in multiple ways. This thesis has focused on the study of creative design meetings, where problems are stated and concepts are created and evaluated.

An effort has been made towards the understanding of how people interact in this kind of meetings. The first goal, then, has been to come up with a reliable method of study an analysis of creative design meetings.
The second goal arises from the study of creative techniques using the appointed method, and is to find out the real needs of interaction in creative design meetings. The hypothesis different creative techniques have different interaction needs while guide us to compare these techniques.

Once the needs of an efficient interaction may be found, we would be able to answer to the question: Which is the most suitable tele-collaboration technologies to perform this techniques in a distributed level? And, in case that it doesn’t exist, we may study how should it be.

The general aim of this thesis is not to follow the path of most tele-collaboration technologies research, which is to create a system that affords us the same richness and variety of interaction that we have when we are physically proximate. Instead, the aim is to come up with useful input for products that go beyond being there (Jim Hollan, 1992), that is, tools that fill our interaction need better than in colocated environments. Only by studying the group interaction, regardless of the medium, we will achieve a truly innovative point of view.

1.2. Scope

This thesis can be framed in the distributed collaboration research. Specifically, concerning tele-collaboration technologies.

The approach is related to engineering product design. It uses some of the methods attached to this discipline, as identifying costumer needs, and establish target specifications. It also has an inspiration from social sciences, related to human-human interaction, and human-object interaction.

The case studies are focused on creative design meetings. These kinds of meetings are carried on by a small group of engineers or designers. They are usually previously scheduled and planned, and performed in the same shared space. The participants may belong to the same company, sharing the same profession, or may have never seen each other before. They can last for 15 minutes or 2 hours.

There is a lot of discussion about the interaction with design objects in these meetings as well, with special attention for sketching. A sketch may imply a fast drawing of an idea or prototype, some annotation in a paper, a concept diagram... Almost anything that can come out of a pen or pencil and a writing surface.

A tele-collaboration technologies review is included as well. A Tele-collaboration technology is a device that permits communication between two or more users placed in different physically located environments. Usually they are computer-based technologies. This review is focused on the features that permit the interaction within users and within users and objects. Highly technical issues, like electronics, informatics, or a detailed study of the interfaces are out of the scope of this thesis.
1.3. Disposition

The disposition of this thesis is as follows;

Chapter 2 includes a theoretical framework, with information related to creative design meetings; they role in the product development process and how designers behave in them. Creativity techniques are introduced as well, with special attention to brainstorming. Chapter 3 explains the general state of tele-collaboration technologies research, and what is the suggested approach in this thesis (beyond being there). In Chapter 4, the analysis method, based on the study of group interaction, is explained and argued. The 5 senses of interaction are defined, quantified, and represented as pentagons. In Chapter 5, the method is applied on analyzing tele-collaboration technologies and creativity techniques. After that, an effort is made on ‘coupling’ techniques and technologies, based on the similarities between pentagons’ shape. Chapter 6 explains the results obtained in Chapter 5, regarding the use of the method, the analysis of techniques and technologies and the coupling between them. Chapter 7 includes the conclusions obtained and suggested future work.
2. THEORETICAL FRAMEWORK

2.1. Product development process

A process is a sequence of steps that transforms a set of inputs into a set of outputs. A product development process is the sequence of steps or activities that a company employs to conceive, design and commercialize a product. Many of these steps and activities are intellectual and organizational rather than physical. Some organizations define and follow a precise and detailed development process, while others may not even be able to describe their processes.

As we can see, in figure 1, the generic product development process consist of six phases (Karl T. Ulrich, 1995):

1. **Planning:** The planning activity precedes the actual launch of the project. It begins with corporate strategy and includes assessment of technology developments and market objectives. The output is the project mission statement.

2. **Concept Development:** In the concept development phase, the needs of the target audience are identified, alternative product concepts are generated and evaluated, and one or more concepts are selected for further development and testing. A concept is a description of the form, function, and features of a product. The most concepts are generated in this phase the better, so here is when creativity methods as brainstorming come into play. This thesis will talk about ways of making early design creativity phases more efficient.

3. **System-level design:** The system-level design phase includes the definition of the product architecture and the decomposition of the product into subsystems and components. The output includes a geometric layout of the product, a functional specification of each of the product subsystems, and a preliminary process flow diagram.

4. **Detail design:** The detail design phase includes the complete specification of the geometry, materials and tolerances of all the unique parts in the product, as well as an identification of the standard parts to be purchased from suppliers. It also gives information about which production system to be used.

5. **Testing and refinement:** The testing and refinement phase involves the construction and evaluation of multiple preproduction versions of the product, as prototypes. They are tested to determine whether the
product will work as designed and whether the product satisfies the key customer needs. Also, production systems are evaluated.

6. **Production ramp-up:** In the production ramp-up phase, the product is made using the intended production system. The purpose of the ramp-up is to train the work force and to work out any remaining problems in the production processes. The transition from production ramp-up to ongoing production is usually gradual, and at some point the product is launched.

### 2.2. Concept development

The Concept Development is considered the first phase of a product design project. This phase include the following activities:

![Figure 2: The different steps of the concept development phase (Karl T. Ulrich, 1995)](image)

- **Identifying customer needs:** The goal is to understand customers’ needs, and to effectively communicate them to the development team. Also, in this phase, possible improvements for an already existing product can be identified, just by direct observation or asking to users. The output of this phase is a list of needs/product improvements, organized hierarchically by importance weightings.

- **Establishing target specifications:** Specifications are the translation of customers needs to technical terms. Each specification consists of a metric, and marginal and ideal values for that metric. For example, a costumer need for a shopping car could be “being able to drive it easily”, while a specification for an engineer might be that “the force needed to turn the car is less than 10 Newton”. The output of this phase is a list of target specifications.

- **Concept generation:** The goal of concept generation is to thoroughly explore the space of product concepts that may address customer needs. Concept generation includes a mix of external search, creative problem solving within the team, and systematic exploration of the various solution fragments the team generates. The result of this activity is a set of concepts. Each typically represented by a sketch and a brief descriptive text.

- **Concept selection:** Concept selection is the activity in which various product concepts are analyzed, with the aim of identifying the most promising.
• **Setting final specifications:** The first specifications set earlier in the process are refined after the concept selection. The team must commit to specify values of the metrics reflecting the constraints inherent in the product concept.

• **Project planning:** In this final activity of concept development, the team creates a detailed development schedule, identifies resources to complete the project, optimizes procedures....

The concept development process can be as well defined as a set of divergent phases, where the solution space is expanded, and convergent phases, where the ideas and concepts are selected and refined (Karl T. Ulrich, 1995), (Banathy, 1996).

![Diagram of divergent and convergent phases](image)

*Figure 3: Designs consists of divergent and convergent phases by Bergström (Bergström, 2009), after Banathy (Banathy, 1996).*

In innovation projects, where the problem is not so accurately defined, the designers and the process must allow for ambiguity in divergent phases, without narrowing down the scope of ideas and possible solutions (Bergström, 2009), in order to achieve more creative concepts.

### 2.2.1 The concept of affordance

In the late years, some researchers in engineering design, as Jonathan R.A. Maier (Maier, 2001), argue that the concept of *affordance* is fundamental to understand product design. In fact, they consider it more powerful than the so well known concept of function, for instance.

The theory of affordances was first put forward by the perceptual psychologist James J. Gibson, as follows: “The affordances of the environment are what it offers the animal, what it provides or furnishes[...] It implies the complementarities of the animal and the environment”. In other words, the *affordances* exist only in the interaction between animals (usually humans) and the environment (in particular, artifacts designers create in the environment). So, and affordance can’t exist without both the user and the object.
An affordance implies an efficient action. The soil affords to walk on it, the water affords drinking, and also, as being fluid, it affords pouring from a container. Donald Norman also claims that an affordance is what something ‘is for’. But in fact is not enough that an artifact enables an action, it should afford it well, in terms of quality. These actions should be perceived easily by the user, the so-called “positive affordances”, while “fake affordances” shouldn’t be perceived.

The concept of affordance provides a wider understanding of the object while designing than the concept of function. This is because the affordances of an artifact are everything we can actually do with, whereas the functions of an artifact are what it is designed for.

2.3. Creative design meetings

The creative design meetings usually occur just after having figured out the customer needs, and having translated them into technical specifications. This is the first creative part of the product development process, where a group of people comes up with new product concepts (in the shape of some sketches and brief text) that solve the customer needs. The aim of these meetings is not restricted to classical design problems and may include solving a financial problem as well, find a new business plan, improve an existing product or system, etc...

There are, then, three elements that define these meetings: the knowledge of the participants, their cognitive skills and limitations, and their communication skills. Therefore, a design process can be seen as an integration of a technical process, a cognitive process, and, more recently, of a social process (Nigel Cross, 1995). In fact, designing nowadays is not faithfully represented as simply the art of applied science pursued by and individual, but as a business group of individuals who, if they are to be effective, must know how to discuss, deliberate and negotiate with others (Bucciarelli, 2002).

It is also important that the participants of a design meeting are as heterogenic as possible (Tom Kelley, 2001, p. 65). In fact, it is recommended that as much stakeholders of the project as possible take part on it, such as engineers of different fields, architects, designers, people from marketing, clients, a customer service rep... even the customers themselves. These participants have different competencies, skills, responsibilities and interests, since they inhabit different worlds, so they see the object differently (Bucciarelli, 2002) while sharing a common goal.

In this phase of product design, the official role of the participants is assigned, having hierarchal relations between them. However, informal role adoption is being developed during the creative sessions, by means of repeated patterns of behavior or types of comments by the individuals. For example, some of the members can take leadership role, or a “centre stage” role, while others are
apparently non active (maybe working independently, drawing or pursuing another line of thought) (Nigel Cross, 1995).

Another interesting aspect of the sessions is that participants, in a sense, are in competition with one another. Sometimes, claims and proposals of one individual will conflict with those of another, and also team members may find it necessary to persuade the others of the value of a concept they particularly favor (usually a concept they generated themselves) (Nigel Cross, 1995).

The creativity techniques used in these kinds of meetings will be explained later in this thesis, but first, we will see which are the common procedures.

2.4. Looking for a shared understanding

One of the first things that a team must come up with is a shared understanding of the problem. That doesn’t imply an agreement of which solution must be achieved, but a common ground of the boundaries, rules, and needs of the product. However, this common ground can be built and rebuilt through the moment-to-moment interaction of team members (H. Clark), in a sort of feedback cycle. This is made thanks to an efficient communication between members, which can be made through different channels, not only verbally, but also using face expressions, gestures, and design artifacts as well.

Mattias Bergström explains in the conclusion of Probing for innovation the phases a group has to go through to reach a common understanding:

“grounding [...] consists of three key activities, namely probing, acknowledging and understanding” [...] Probing allows both the problem and plausible solutions to be explored [...] by acknowledging the probes, the team can boost or disrupt the creative flow [...] a contrasted understanding is used as inspiration for further ideation”

Probing for innovation: How Small Design Teams Collaborate, p. 63 (Bergström, 2009)

As explained in “What’s the problem?” (Stephanie Ottenheijm, 1998), the problem solving capability of a group is defined by their understanding of the problem and their agreement. A group with both high understanding and agreement, can take effective and efficient actions about the problem. That’s the case of the “decision making” phases of a designing process, as for example when performing “Evaluation techniques” (see Appendix 2- Creativity techniques review, p. 65-68)

However, some other researchers argue that a team of designers with little common understanding and agreement come up with a wider set of ideas and concepts, often new, often unexplored (E. Arias, 2000). Consequently, “the
differences in opinion are a source of inspiration” (Bergström, 2009, p.63). Also, not much knowledge about the problem to be solved leads to a wilder and more unlikely solutions.

The other case scenarios are when there is high understanding and no agreement, then we have conflict in the group, and when there is high agreement but no shared understanding, then groupthink can occur. In this case, the group frame is not a good representation of the group’s understanding of the problem situation. However, group members say they agree, just for the sake of the group.

Most of the non-understanding situations between designers are caused by a deficient problem definition. This can be solved by using “What’s the problem?” techniques (see Appendix 2- Creativity techniques review, p. 61-62) usually performed at the beginning of a creative session.

All these situations are pictured in the following matrixes:

![Figure 4: Understanding-Agreement problem framing matrix (Stephanie Ottenheijm, 1998)](image)

1. “Shared understanding and agreement”; this means the problem is framed and the group can “decide now”
2. “Understanding but no agreement”; conflict
3. “Agreement but no shared understanding”; groupthink
4. “No shared understanding and no agreement”; uncertainty and ambiguity

2.5. Design objects

One important issue on collaborative design is the use of artifacts. Artifacts allow the externalization and representation of objectives, constraints, form, function, assembly, materials, and so on (Hutchins, 1995). Examples of artefacts are pen and paper sketches, tables of data, guidelines, cardboard models, and visualisations produced by CAD applications or virtual reality technology. These artefacts can be
divided in two groups: design artefacts, including plans, models, prototypes, and visualisations, an procedural artefacts, which may include forms, change requests, office memos, letters and schedules, and Gantt charts.

Artefacts are the objects of interaction; they have an important role as a communicative resource. They become the terrain on which conflicts and collaboration occur. Agreements are reified in artefacts (Perry, 1998). Design artefacts become the common object world language in design process (Bucciarelli, 2002), where participants usually come from different world objects (e.g.: Electric engineering, architecture, manufacturing). This means, they are the vehicle of expression and shared understanding of the object of design.

Robin Wolff et al. define shared object manipulation as “the simultaneous action of modifying an object through its attributes, such as position or colour” (Robin Wolff, 2005, p. 5). They distinguish between two classes of shared object manipulation: sequential and concurrent manipulation. Sequential manipulation occurs when attributes are modified in sequence, whereas concurrent manipulation occurs when attributes are modified simultaneously. They also classify scenarios where simultaneous actions are independent and co-dependent. Independent actions are those where distinct object attributes are modified. Co-dependent actions are modifications of the same object attribute. An example of independent action is when two people are together painting an object where one person controls the position attribute by holding the materials in place, while another controls the colour attribute by holding the material in place, while another controls the colour attribute by painting it. An example of concurrent manipulation is the joint lifting of heavy object where the position attribute is dependent on both participants’ actions.

It is important that design objects have comprehensive interfaces, which are the frontier between our cognitive skills and the information and functions that the artefact can provide. Then, it is necessary to use our communicative skills to share this information with the others.

2.5.1 Prototyping

Sometimes prototypes are understood as faithful representations of the final product, and focus too much attention on things such as what tool was used to create them, and how refined-looking or –behaving they are. Prototypes can be really useful in design meetings if we look at them in terms of the product being designed, rather than the prototype’s incidental attributes.

We can define prototype as a representation of a design idea, regardless of the medium. They provide the means for examining design problems and evaluating solutions (Stephanie Houde, 1997). In other terms, they are design artifacts, which can present any shape as long as they express some feature of the future product.

The prototype can approach these features, according to S. Houde, by 3 different ways: as role, look and feel, and implementation. “Role” refers to questions about in which way the artifact is useful to the user’s life, “Look and feel” denotes questions about the concrete sensory experience of using an artifact-what the user
looks at, feels and hears while using it, and “Implementation” refers to questions about the techniques and components through which and artifact performs its function.

![Figure 5: A model of what prototypes prototype (Stephanie Houde, 1997)](image)

A prototype may explore questions or design options in one, two or all three dimensions of the model. Also, separate prototypes can be made that may be situated in different parts of the triangle. This procedure gives the chance to work in parallel by different design teams working in different aspects of the final product. None of these teams will probably reach a definitive solution, but they’ll obtain input information to an integrated design. It is more efficient this way than try to build monolithic prototype that integrated all features.

Anything can be a prototype: a rough sketch, a cheap foam model, a totally unrelated product that already exists... as long as they give some clear information about how the final product will look like, behave, adapt to users needs, etc. As Kelley points out, “what counts is to express the idea quickly and cheaply” (Kelly, 2001)

### 2.5.2 Sketching

Sketching is a design tool. It implies the use of the hand, a pointer/marker object, and a flat surface. When we are sketching, we try to represent our mental image of an object or a concept by drawing lines over the surface, while holding the pointer
and by using our cognitive skills. A good sketch is not a meticulous drawing of how the product would be, but a few fast lines that show the most relevant features of the product/concept.

**DRAWING TECHNIQUES**

- **Do some warm up:** Get used to the pen by drawing some simple forms before start sketching. Make some circles for example, trying to repeat the same form until it is round.

- **Visualize the lines before drawing:** Make with the eye and the hand the trajectory you want to trace with the marker a couple of times before drawing the actual line.

- **The three pivots in our arm:** The shoulder, elbow, and wrist are three pivots that allow us to trace precise curves of three different radiuses.

- **Move the paper, not the arm:** Move the arm the least you can, but keep rotating the paper and moving it around instead. You can apply this technique while drawing curves and straight lines for instance. It is important to trace few but well learned trajectories.

- **Use different pen thickness:** Use a thin pen to draw most of the lines and a thick one to remark the important shapes and contours.

*Figure 6: Techniques for efficient drawing*

Sketches are an important tool to use in brainstorming sessions (early design meetings), since they provide a shared understanding in the design team. Sketching also supports re-interpretive thinking cycles and access to earlier ideas. It enables the designer to draw *prototypes* of the final product in an easy and fast way.

### 2.6. Group interaction

Product design implies social interaction, whilst it is carried on by a group of engineers, designers, stakeholders, etc... These people need to share their knowledge (technical, and non-technical) in order to work around ideas and concepts. That’s why communication is so relevant in design meetings. As Larsson points out, “the social character of design activity is not separated from the technical results” (Larsson, 2003).

A group of people may need to interact in a number of ways. Ellis (C. A. Ellis, 1991) categorized group interactions according to a time/location matrix, illustrated on figure 6. Within this matrix, a distinction is made between same time (synchronous) and different times (asynchronous), and between same place (face-to-face) and different places (distributed). The taxonomy reflects the diversity of closeness of ‘coupling’ of geographical spread within teamwork.
When speaking about creative design meetings, usually we focus in the same time interaction cell column. Both same place interaction and different places are studied in this thesis, since usually distributed communication technologies try to emulate co-located interaction.

In co-located communication, we are used to keep our partner in our vision field all the time. Communication channels as gestures, facial expressions, eye contact and gazing or pointing help to find a common ground when explaining and debating concepts. Also, co-located meetings enable useful forms of communication like embodiment. That means, use your body to express ideas and concepts in a more efficient way. It can be combined with verbal language, and also can imply the interaction with design objects. The feeling of presence effectiveness is proved in co-located meetings. In the appendix section (Appendix 1- Scenario 1 (Matias Bergström, 2007)) an example of co-located meetings is explained.

In distributed meetings, then, presence need to be modeled. In Experienced Presence within Computer-Mediated Communications (Stef G. Nicovich, 2005), the authors define Presence as the result of immersion in the CMC environment, in which the artificial environment impacts a participant in place of the natural environment. According to Steuer (Steuer, 1995), vividness and interactivity are the two basic elements that contribute to level of immersion in the CMC channel. Vividness refers to the impact of the senses being accessed and the quality of the experience, and interactivity is the extent to which users can participate in modifying the form and content of a mediated environment. As for how a person receives and analyze the information, Nicovich et al. use the concept of Empathy, defined as “the ability to project oneself into another”(Stef G. Nicovich, 2005). They argue that both Empathy and Presence are closely related in a CMC communication since “higher levels of empathic ability will lead to higher levels of experienced presence”.

Ijsselsteijn and Riva (Wijnand Ijsselsteijn, 2003) divide presence in two categories: physical and social. Physical presence refers to the sense of being physically located in mediated space, whereas social presence refers to the feeling of being together, of social interaction with a virtual or remotely located communication partner. At the intersection of these two categories, they identify co-presence or a sense of being together in a shared space, combining significant characteristics of

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<td>Different Places</td>
<td>Synchronous distributed interaction (shared editors, video windows)</td>
<td>Asynchronous distributed interaction (e-mail, bulletin boards)</td>
</tr>
</tbody>
</table>

*Figure 7: Group interaction time/location matrix by Ellis (C. A. Ellis, 1991)*
both physical and social presence. An example of a technology that enables physical presence is TV, a technology in the social presence category would be the telephone, and a technology that combines both components is Videoconferencing.

A workspace, where the group interaction takes place, is not only defined by its physical boundaries, but by the lived relationship between the people in the space (Bergström, 2009). In some environments, like in co-located meetings, individuals can change quickly between a local conversation and discussing the general topic with the rest of the designers. Also, team members’ position or presence in their work environment at a given time should provide indication to the others of their focus of concern, or they level of activity (Mark, 2002). For instance, a designer sitting far away from the whiteboard in a creativity session express low level of activity, or maybe that he is working in another approach to the problem, while standing next to it express and active input to the idea creation. Sharing the manipulation of objects is afforded as well, and requires a certain level of proximity between collaborators and objects, and often a level of mobility within the workspace is necessary as well (Robin Wolff, 2005).

2.7. Creativity techniques

2.7.1. Creativity

Creative thinking refers to how people approach problems and solutions- their capacity to put existing ideas together in new combinations. The skill itself depends quite a bit on personality as well as on how a person thinks and works. Also, achieving success in ideation depends strongly on the personal motivation on solving the problem.

As Edward de Bono (expert in strategic and creative thinking) claims, the way to find creativity is “Thinking outside the box”:

“We are all within a certain box framed by constraints, by expectations, by perceptions and concepts we use [...] we should break out the box in order to get unexpected ideas, out of our usual behavior and thinking”

Edward de Bono on Creative Thinking, http://www.youtube.com/watch?v=UjSjZ0jNlJg

For this purpose exist, however, several creativity techniques to help us breaking outside the box (see Appendix 2- Creativity techniques review, p. 62-65). Some techniques are used to know what the problem is and come up with a general direction of attack, and some other’s goal is to generate as much ideas and solutions to the problem as possible.

However, in business creativity, and idea can’t be just original, it has to be appropriate- useful and actionable. It must somehow influence the way business gets done- by improving a product, for instance, or by opening up a new way to approach a process (Amabile, 1998). That’s why it is necessary an evaluation phase
after the concept creation, since usually only one or two ideas, amongst the hundreds, may be really implemented as a solution.

2.7.2. Brainstorming sessions: Rules of the game

Brainstorming is possibly the most important procedure in concept creation. It is an opportunity for teams to “blue sky” early in a project, or to solve a tricky problem. It is a group technique designed to generate a large number of ideas for the solution of a problem. (Wikipedia). A brainstorming session has its own rules and idiosyncrasies, which can be applied to any creative technique, except the one about duration and the number of participants.

These are some of the well-known ground rules for brainstorming, designed to create a creative mood in the meeting:

- **Focus on quantity:** The greater number of ideas is generated, the greater the chance to produce a valid solution.
- **Keep the record:** Someone should write down all the ideas as they occur.
- **Withhold criticism:** Always look at ideas in a positive way, by adding and extending them. Reserve criticism and judgment for a later ‘critical stage’ of the process.
- **Welcome unusual ideas:** Wild ideas are welcome. They can make the participants approach to the solution from different perspectives.
- **Combine and improve ideas:** 2 average ideas combined can generate a single really good idea.

However, brainstorming sessions rules are far more extent than that, if we really want it to be productive. As Kelley explains in *The Art of Innovation* (Tom Kelley, 2001), “the problem with brainstorming is that everyone thinks they already do it [...] most of people are familiar with the fundamentals-like sticking to one conversation at a time and building on the ideas of others- but it takes extra effort if you want a great brainstormer (a brainstorming session) with valuable results”.

> “the problem with brainstorming is that everyone thinks they already do it [...] most of people are familiar with the fundamentals-like sticking to one conversation at a time and building on the ideas of others- but it takes extra effort if you want a great brainstormer (a brainstorming session) with valuable results”.
>
> The Art of Innovation, p.55 (Tom Kelley, 2001)

Kelley reveals some hints to perform an efficient brainstorming session:

- **Duration:** Sixty minutes seems to be the optimal length, being able to stretch it to an hour and a half. It is difficult to keep for much longer the mental activity required. However, sessions may go on until all the ideas have really dried up, and all the methods of stimulating new ideas have been used.
• **Sharpen the focus:** It is important to have an accurate definition of the problem. It should not be too narrow, neither too fuzzy, “something tangible that participants can sink their teeth into, without limiting the possible solutions”.

• **Number your ideas:** It motivates participants during and before a session, fixing a goal. Kelley claims that a good brainstormer comes up with a hundred ideas per hour. The limit use to be in one hundred and fifty concepts per hour. It is also a good technique in order not to lose the track.

• **Build and jump:** A brainstorming session usually has different power curves, concerning the amount of ideas generated and the heat of the conversation. It is the duty of the “facilitator” to keep on the prolific phases in the session by asking to the participants for a new point of view concerning a given subject, or a given feature of the product. It is also necessary to “jump” for another subject when the energy starts to decrease.

• **The space remembers:** Spatial memory is important for brainstormers. It should a person in charge of writing the ideas down in a medium visible for the whole group. Kelley notes that old-tech tools, as giant Post-its on the walls or sharpie markers, have achieved great success. If you write down an idea in a certain spot of the wall, returning to that point may help to catch it again later in the session.

• **Stretch your mental muscles:** Kelley recommends to do some warm up before a session, specially if the group has not worked together before, when most of the group doesn’t brainstorm frequently, and when they seem distracted by pressing but unrelated issues. He explains some techniques to do that, such as do some previous group as listening to some expert speak about the subject, or going to a shop to look for related products.

• **Get Physical:** Use any available tools at hand in order to be visual with your ideas. This includes sketching, mind mapping, diagrams, embodiment… (some of these techniques are widely explained in this Thesis). But also it is recommended to bring into the session any related object you may find: competitive products, elegant solutions from other fields, and promising technologies that could be applied to the problem. You can also bring in materials to build fast prototypes.

Kelley ends his advice pointing out that brainstorming, as any art, must be trained in order to master it, but its benefits are uncountable. Being good at brainstorming changes the way in which you approach to problems, and helps you find faster solutions.

Rawlinson (Rawlinson, 1981) also points some indications for an efficient brainstorming session.

• **Number of participants:** Rawlinson recommends the maximum number of participants to be 20, so everybody has the chance to contribute ideas, and the minimum number to be 5, so the laughter-freewheeling atmosphere can still be achieved.

• **Avoid speaking in turns:** Idea generation happens randomly, and as Kelley points out, there may be some phases in the session where idea generation accelerates. This must be encouraged and not invalidated by trying to make all the participants to speak the same amount of time.
As a creativity technique, which aim is to generate as many ideas as possible, brainstorming is usually out of control. Paradoxically, the control of brainstorming session generates more, not less, ideas.

Bergström includes in his thesis *Probing for Innovation* (Bergström, 2009) an explanation of how embodiment works in Brainstorming sessions:

- **Bodystorming**: Bodystorming is a participatory method for demonstrating or developing ideas in a physical setting. A bodystorm is created as someone embodies a concept and the group plays along, building on each other’s embodiment. They question the concept as a plausible solution and also challenge the design task as they experience the concept from a user’s position. The process is designed to uncover how the relationships between people, locations and things affect ideas in ways that written scenarios cannot. It enables rapid iteration of ideas and relationships through a dynamic process of acting and evaluating.

The figure of a **facilitator** is also required in some creativity techniques as Brainstorming. The facilitator or ‘leader’ is a member of the creativity session group, so he must be prepared to contribute with ideas, but he is in charge to ensure that the rules to encourage creativity are being applied correctly, particularly **suspend judgment**. He should keep record of ideas in a quick and visible way. Most of all, though, he is in charge of keeping up the freewheeling and laughter atmosphere of the session (Rawlinson, 1981).

### 2.7.3. Evaluation

After performing a brainstorming session, which always focus on coming up with as much ideas as possible, its time to identify the really good ideas amongst the many inappropriate, ideas.

Unlike brainstorming, the process of evaluating ideas is cold and analytical, in which barriers go up, parameters are fixed and ideas that fall outside the barrier are discarded quite ruthlessly. It is recommended to perform the evaluation of ideas one or two days after the brainstorming sessions, in order to look at them with fresh eyes.

### 2.7.4. Creative techniques categorization

There are lots of creativity techniques. The selection included in this Thesis tries to be as heterogenic as possible (see Apendix 2: Creativity techniques review, p.61-68). For instance, there are some techniques that help us achieving a better understanding of the problem, which is, creating a common ground between designers. And still, in this phase can appear some new points of view not considered before. That’s what we call “What’s the problem” techniques. Others encourage the creation of as much solutions as possible, “How to solve the
“problem” techniques. They are characterized for being performed in freewheeling sessions, usually full of fun and laughter, where judgment is not allowed. After the creativity phase, comes the Evaluation of ideas, which some techniques include on its procedure. Its aim is to bring the best ideas, usually wild, to a realistic, constrained, level.

Some of these techniques can be performed either individually or in a team. However, the best way of getting new perspectives and “thinking outside the box” is to make group sessions.

There is a differentiation of whether sketching is allowed while performing the technique or not, and whether the figure of the facilitator is needed or not.

Apparently, all these techniques are designed for co-located meetings. Nevertheless, later in this thesis we will study how well telecommunication technologies can be used to perform these sessions by distributed teams.

<table>
<thead>
<tr>
<th>What is the problem</th>
<th>How to solve the problem</th>
<th>Evaluate the solution</th>
<th>Facilitator needed</th>
<th>Session Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word association</td>
<td>•</td>
<td>•</td>
<td></td>
<td>10 min</td>
</tr>
<tr>
<td>Obstacle map</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>15 min</td>
</tr>
<tr>
<td>Army of thousand</td>
<td>•</td>
<td>•</td>
<td></td>
<td>15 min</td>
</tr>
<tr>
<td>Classical Brainstorming</td>
<td>•</td>
<td></td>
<td>•</td>
<td>2 hours</td>
</tr>
<tr>
<td>Brainwriting / Brainsketching 6-3-5</td>
<td>•</td>
<td>•</td>
<td></td>
<td>30 min</td>
</tr>
<tr>
<td>Visual Brainstorming</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>1 hour</td>
</tr>
<tr>
<td>Classical brainstorming Evaluation</td>
<td>•</td>
<td></td>
<td></td>
<td>2 hours</td>
</tr>
<tr>
<td>The hundred dollar test</td>
<td>•</td>
<td>•</td>
<td></td>
<td>10 min</td>
</tr>
<tr>
<td>6 thinking hats</td>
<td>•</td>
<td>•</td>
<td></td>
<td>30 min-1hour</td>
</tr>
</tbody>
</table>

*Figure 8: Creativity techniques categorization*
3. RESEARCH FRAMEWORK

3.1. The challenge of distributed communication

It has been acknowledged that design process is an integration of a technical process, a cognitive process, and a social process. We have previously talked about the importance of an efficient communication between design meetings. In co-located scenario, facial expressions, gaze, pointing, posture, gestures, embodiment representations... provide additional communication channels. Furthermore, shared objects and the environment around the participants can be used for a communication. Since in a co-located scenario these channels are usually natural and fluid, we come upon trouble when going distributed.

In distributed meetings, communication needs to be made through devices (e.g.: computers, telephones, video-conferencing equipment, etc...). That is, we are arranging an interface between designers. This interface gives a specific amount of sensory input and output channels (Zelter, 1992). Since we are placing this technological barrier, telecommunication won't ever be as intuitive and fluid as co-located communication.

Moreover, the early, creative, conceptual design phases are typically non-structured, requiring a lot of ad hoc interactions and highly interactive meetings relying on swift and unrestricted information exchange (Peter Törlind, 2005). It is also apparent than living and working near others, whether that be in the same house, adjacent offices, or the same city, affords certain opportunities for interaction that are unavailable to those not co-located.

Building and maintaining trust between members is also easier in smaller groups. When following large distributed projects in industry, the interaction between groups is usually restricted to only a managerial level. Design influence between groups is rather small, often restricted to the interfaces between the groups' respective responsibilities (Peter Törlind, 2005).

Many of the telecommunication research seek to approach distributed communication into a co-located level, that is, to allow the same richness and variety of interaction, but with distance no longer an issue. In order to achieve that, technology “must convey interaction, attention and awareness with reference to others, shared objects and the environment” (Robin Wolff, 2005, p. 7).

3.2. Beyond being there

In the recent years, most telecommunication technologies have tried to solve the problem of non physically co-located communication by creating a sense of being
there, establishing some form of audio and video connections between two distant locations.

As Jim Hollan and Scott Stornetta point out in *Beyond being there* (Jim Hollan, 1992) in one important respect, systems designed using this approach may never be “close enough”. When you have the choice between face-to-face and an imitation, no matter how good, it is natural to choose the real thing. This it is particularly telling for communication. If one channel is half as good as another, we don’t use it half as often, we probably don’t use it at all, so long as the other is readily available. To make a real progress on the telecommunication problem, they argue, we must develop tools that people prefer to use even when they have the option of interacting as they have heretofore in physical proximity. We must develop tools that go beyond being there, with a higher and more efficient information exchange than face-to-face.
4. ANALYSIS FRAMEWORK

*Design shapes the designer as much as the designer shapes the design*  
(Bailey)

4.1. The five senses of interaction

In order to analyze creativity techniques and tele-collaboration technologies, we will define the five senses involved in the interaction between designers, designers and design objects and designers and the environment, which are; **Sense of presence, Sense of space, Sense of time, Sense of sharing and Sense of naturalness.**

The understanding of **sense of presence** in this thesis is similar to the definition of *social presence* by Ijsselsteijn and Riva (Wijnand Ijsselsteijn, 2003): “*social presence refers to the feeling of being together, of social interaction with a virtual or remotely located communication partner*”. We consider, at the same time, that social presence is built by means of communication channels, such as spoken language, written messages, sketching, embodiment, and the awareness of our interlocutor. Obviously, both factors are strongly coupled, since highly interactive communication channels like eye gazing need of a high awareness.

Ijsselsteijn and Riva define **physical presence** as “*the sense of being physically located in mediated space*”. The combination of both forms a co-presence, which is the case of technologies as Virtual Reality or Video-Conferencing. In this thesis, *physical presence* is evaluated by the **sense of space** and **sense of sharing**.

**Sense of space** will be considered as the interaction between the designer and the environment, where all the design activities occur. In a good environment, we can walk around, see other people’s creation, find our own room for thinking or our room for acting, etc. We can easily and quickly contribute to the design creation, with no need to move long distances. We are able to look at design objects from different view angles as well, and access them from any angle. The awareness of the position of the other designers informs us of the level of activity and the focus of concern.

**Sense of sharing** is defined as the interaction possibilities around design objects. Since design objects help to create a common ground of the problem, they should be shareable and modifiable by all the designers. A private/public modality of design object’s sharing should be “afforded”, as well as “custom” views concerning different properties, the object’s creator, old versions, etc. It is important that communication between designers is being made simultaneously to object sharing.
**Sense of naturalness** is defined as the interaction between the designer and the interface of the *medium of collaboration*. This means, for instance, how intuitive is to use the new videoconferencing system implanted in the conference room, or how easy is to sketch on a digital whiteboard. Naturalness of human-computer interaction is likely to increase performance, because people do not need to compensate for the technology, allowing the users to concentrate more on the task, not the interface. That is, users should be able to use their already learned skills in a natural way, without noticing the technology as a challenge. Scientific disciplines as CSCW (Computer Supported Cooperative Work) seeks to understand how people work together in order to design adequate computer-based technologies for cooperative tasks.

We define **Sense of time** as the quality of time continuity while communicating. While sharing the same space, time is not a big issue of concern, since the transmission of information is synchronously shared. However, in distributed communication, to avoid time delays is mandatory for a fluent and comprehensible exchange of information. Moreover, if the teams are spread over different time zones, it could be necessary to find the right time interval that overlaps different team's work hours (Peter Törlind, 2005). In an asynchronous communication, like an e-mail conversation, time is not an important restriction anymore.

Even though some of these aspects of communication may seem not to apply to physically located meeting, like **Sense of naturalness**, studying every medium with the same principles, both co-located and distributed, both physical and computer mediated, may reveal which aspects could take benefit one from the other.

The motivation of defining these senses is that they cover pretty much every aspect of the interactions conducted in a design meeting, allowing us to analyze both creativity techniques (in which case the senses become *needs*) and tele-collaboration technologies (in which case the senses become technique features).
4.2. The *pentagons* analysis method

The idea proposed is to represent creative techniques and tele-collaboration technologies using pentagons, assigning each one of the senses to one of its vertex. In the case of creative techniques, the senses represent interaction needs, and in the case of tele-collaboration technologies, they describe *permitted* interaction features. To analyze them using the same visual method will arise useful information, and a starting point in order to ‘couple’ them.

The senses will be evaluated by different levels, usually from 0 to 5 (except *sense of naturalness* which is from 0 to 3). Each of these levels represents a different group interaction situation.

Generally, a higher degree stands for an interaction closer to the physically located. However, as we pointed out before in “Beyond being there”, that’s not always the best solution. For instance, level 2 for *Sense of time* would be an asynchronous instantly shared communication, as when using e-mail. From level 3 we speak about a synchronous communication for sense of time, as in videoconferencing.

*Figure 9: Computer mediated human interaction scheme*
However, e-mail is one of the most successful telecommunication technologies nowadays, and its asynchronous communication has several advantages over videoconferencing (e-mails usually contain formal information that can be reused, quoted, etc., and both sender and receiver don’t have to be simultaneously online to start a conversation).

In some cases, like in Sense of sharing, we also observe that CMC offers obvious advantages over physically located communication. For instance, in a digital medium we can layer design objects, retrace them, and observe them in different views. These actions are not possible in co-located meetings.

Concerning the Sense of naturalness, it takes slightly different meaning when talking about Computer-Based communication, and when talking about design and creativity methods. In the former, it refers the ability of the technology to “afford” the already acquired techniques and methods of the designer. When talking about design methods, it refers to the “allowance” of the method to use these knowledge. The reason why it only has 3 levels instead of 5 like the other senses is because it doesn’t need such high level of detail to be described in an interaction situation.

It is important to point out that some of these senses are related between them. For instance, if we are having a Voice communication (that is level 2 for sense of presence), inevitably we will have a third level or upper for sense of time, since it will surely be a synchronous communication. On the same page, if we have level 4 or 5 for sense of space (which means that we can either view or modify design objects from any position in the environment), sense of sharing level will be at least 1 in the first case and at least 4 in the second case.

4.2.1. Sense of Presence

0: No communication channels available
1: Online/Offline signal - Written messages
2: Voice communication
3: Voice and video communication
4: Non-verbal cues like embodiment, eye gazing/contact, pointing...
5: Integration of interpersonal space and workspace (simultaneity in designer-to-designer communication and design object sharing and modification)
4.2.2. Sense of Space

0: No sense of space
1: Movement around the space allowed
2: Awareness of the other designers level of activity and position in the space
3: Swift between side conversations and public conversations enabled
4: View of design objects from any position in the environment (co-located design meeting in Appendix 1-Scenario 1)
5: Manipulation of design objects from any position in the environment (Tablet PC’s in Appendix 1-Scenario 2)

4.2.3. Sense of time

0: No time sharing
1: Asynchronous communication. The information is received not instantly
2: Asynchronous communication. The information is received instantly
3: Synchronous communication with time delays
4: Synchronous communication without time delays
5: We can go “back in time” on a design meeting (time machine feature)
4.2.4. Sense of sharing

0: No object sharing
1: Design objects can be viewed
2: Design objects can be discussed, working as a common ground
3: Private/Public modality can be chosen
4: Design objects can be modified by all the designers
5: Different views of the same design object can be performed at the same time. Views from different angles, layered views (the creator of the design object can be shown), they can be retraceable, modifiable...

4.2.5. Sense of naturalness

0: Incomprehensible communication
1: Unfriendly interface
2: Friendly interface, unnatural affordances
3: Natural techniques, as sketching, grouping, browsing... enabled in an intuitive way
5. ANALYSIS OF CREATIVITY TECHNIQUES AND TELE-COLLABORATION TECHNOLOGIES

5.1. Analysis of creativity techniques

The creativity techniques are analyzed now. Most of them comprehend different stages, with their corresponding interaction needs. Further information about these techniques can be found in the Appendix 2-Creativity techniques review (p. 61-68).

5.1.1. Word association

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

**Write the topic in the whiteboard** | **Create a topic map** | **Votes are made for important topics**

**Comments**

Stage 1 to 3: As the stages go on in this technique, the sense of time and sense of sharing requirements increase, since it is necessary a closer interaction with design objects (emit votes).
5.1.2 Classical brainstorming

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
<td><img src="image3" alt="Image" /></td>
</tr>
<tr>
<td>State the problem and discuss</td>
<td>Approach the problem in terms of “How to…”</td>
<td>Select a restatement of the problem and write it down</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 4</th>
<th>Stage 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="Image" /></td>
<td><img src="image5" alt="Image" /></td>
</tr>
<tr>
<td>Brainstorming</td>
<td>Create a list of the “wildest idea” achieved</td>
</tr>
</tbody>
</table>

**Comments**

*Stage 1 to 3:* There is still no idea generation, so there is no need for a high *presence* level, or *sense of sharing.* Sense of *space* decrease as the problem is state, since less side-conversations are necessary.

*Stage 4:* Brainstorming sessions need high levels of communication efficiency. The interaction between designers should be through as much communication channels as possible and design objects must be shareable and modifiable in a quick, synchronous way. The chaotic nature of a brainstorming session causes the highest sense requirements.
5.1.3. Brainwriting 6-3-5

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Stage 1" /></td>
<td><img src="image2" alt="Stage 2" /></td>
<td><img src="image3" alt="Stage 3" /></td>
<td><img src="image4" alt="Stage 4" /></td>
</tr>
<tr>
<td>Everyone writes the problem topic on his sheet</td>
<td>Write 3 ideas in 6 minutes</td>
<td>Pass the worksheet and write 3 more ideas</td>
<td>Repeat the process until the sheet is finished</td>
</tr>
</tbody>
</table>

**Comments**

The requirements for this technique are very low, since there is barely the need of interaction between designers. The interaction between designers and design objects should afford private and public sketching/writing though, and time delays are allowed as well.

5.1.4. Evaluation of classical brainstorming

<table>
<thead>
<tr>
<th>EVALUATION BY ALL THE PARTICIPANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
</tr>
<tr>
<td><img src="image5" alt="Stage 1" /></td>
</tr>
<tr>
<td>A list of the ideas are given to the participants</td>
</tr>
</tbody>
</table>

**Comments**

In the evaluation by all the participants there’s no direct discussion (the evaluation is made by voting), that’s why the presence and sharing requirements are low.
<table>
<thead>
<tr>
<th>EVALUATION BY A TEAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
</tr>
<tr>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td>Choose, without discussing, the best ideas</td>
</tr>
</tbody>
</table>

**Comments**

*Stages 2-4:* When performing a team evaluation there’s a lot of discussion on the ideas, which are the design object in this case, so the *presence* needs are high.

*Stage 2:* A grouping stage, probably using post-it’s, that needs high levels of interaction.

*Stage 3-4:* A *time machine* feature (*sense of time’s* level 5) will be very useful in order to remember where ideas come from.
5.2. Analysis of tele-collaboration technologies

Tele-collaboration technologies are analyzed now, next to a short description of their main features. Further information about these techniques and a features’ chart can be found in Appendix 3- Tele-collaboration technologies review (p. 69-75)

5.2.1. Team Work-Station 2 (Hiroshi Ishii, 1994)

The Team WorkStation 2 enables a face-to-face communication between 2 designers, as well as a shared surface for sketching. Every designer draws on their own surface and the images are overlaid on the computer screen, as well as both designers’ video image.

5.2.2. ClearBoard 2 (Hiroshi Ishii, 1994)

Figure 10: Design session via TeamWorkstation-2

Figure 11: Clear Board 2 in use
The main feature of the **ClearBoard-2** is the integration of interpersonal and shared workspace, which is a sketching surface. The designers can sketch on a transparent screen, using a computer-based paint editor that permits recording results, the use of different pointers, layered sketching...

### 5.2.3. Roomware (Thorsten Prante, 2004)

**Figure 12: Dyna wall being used**

**Roomware** is a virtual work environment consisting in several devices with digital surfaces controlled by a pen, like the Dyna Wall, shown in the picture. The devices are interconnected via wi-fi. A software permits private and public creation and manipulation of shared design objects. The only awareness information from the other designers is their pointer.
5.2.4. The distributed designers outpost (Katherine M. Everitt, 2003)

The designers’ outpost is a remote collaboration system that uses post-its as interaction primitives. The physical post-it’s in one location become digital on the other and vice-versa, using a double video camera system, that also shows the shadow of the designers. Drawing in the board is enabled as well, using a digital pen with transient ink.
Spatially immersive displays (SID) (Robin Wolff, 2005)

Figure 14: Interaction with design objects in SID environments

Spatially immersive displays (SID) provide the user the feeling of being inside a 3d environment, in the shape of an avatar. Some non-verbal cues, as body language are enabled, as well as movement towards and around objects. Their objective is to achieve the most natural possible object manipulation and creation, where concurrent and independent actions are permitted. The actual devices are far from obtaining this goal though, and the tools inside these environments are often very crude and are difficult to understand. Object creation is not intuitive.
5.2.6. Other technologies

**Audio-conferencing**

“The telephone is an ubiquitous technology, but it has severe limitations supporting essential social cues and object sharing” (Robin Wolff, 2005)

**Video-conferencing**

“Video-conferencing allows multiple remote people to participate in a tele-conference by exchanging live audio and video data between remote sites. The non-verbal communication is limited. It often has delays in the transmission” (Robin Wolff, 2005)

**E-mail**

“E-mail communication is the paramount success of computer-mediated informal communication. It exploits the asynchronous nature of the electronic medium rather than attempting to imitate synchronous physical interactions” (Jim Hollan, 1992).
5.3. ‘Coupling’ analysis and discussion

Once we have analyzed each creativity meeting and each technology, we are ready to try to match each stage of the techniques to the most suitable technology, by the resemblance of their pentagon shape.

<table>
<thead>
<tr>
<th>Word association</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Pentagon Shape" /></td>
</tr>
<tr>
<td><img src="image2" alt="Pentagon Shape" /></td>
</tr>
<tr>
<td><img src="image3" alt="Pentagon Shape" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The distributed designers outpost</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="Pentagon Shape" /></td>
</tr>
</tbody>
</table>

**Discussion**

The way the design objects are created in the designers outpost seems to suit the needs of the word association technique. Its low capability of modifying the other team’s post-it’s doesn’t seem a drawback since designers only need to modify their own design objects, the others only need to be viewed.
<table>
<thead>
<tr>
<th>Classical brainstorming - Stages 1 to 3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Videoconferencing</td>
<td>Discussion</td>
<td></td>
</tr>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td>Videoconferencing affords well enough the needs of the first stages of brainstorming, since it is basically a communication between designers to build a common ground. However, more spatial awareness will be desirable. For the last stage, when the wildest ideas are listed, videoconferencing can provide the necessary channels to keep the laughter going on.</td>
<td></td>
</tr>
<tr>
<td>As for the Brainstorming session, the highest sense level is needed, only affordable nowadays by spatially immersive displays, which still need to be developed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classical brainstorming - Stages 4 to 5</td>
<td>Spatially immersive displays</td>
<td></td>
</tr>
<tr>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
<td></td>
</tr>
</tbody>
</table>

44
<table>
<thead>
<tr>
<th>Brainwriting 6-3-5</th>
<th>The distributed designers outpost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion</td>
<td>Brainwriting 6-3-5 does not have high requirements in terms of presence, but it does need a private/public shared space, afforded by the designers outpost.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASSICAL BRAINSTORMING - Evaluation by all the participants</th>
<th>E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion</td>
<td>The asynchronous, private nature of the evaluation by all the participants makes e-mail stand out as the most suitable tele-collaboration technology.</td>
</tr>
</tbody>
</table>
### CLASSICAL BRAINSTORMING- Evaluation by a team

<table>
<thead>
<tr>
<th><img src="image1.png" alt="ClearBoard-2" /></th>
<th><img src="image2.png" alt="Roomware" /></th>
<th><img src="image3.png" alt="Discussion" /></th>
</tr>
</thead>
</table>

### ClearBoard-2 + Roomware

Discussion

In the evaluation by all the participants there is a high presence-required public discussion over ideas (design objects). ClearBoard-2 provices the integration of interpersonal and shared worskape necessary for this porguse, though the state-of-art models only allow communication between two designers, and they can only modify their own sketches. To add the Roomware software features, that permit object maipulation by all the designers and the use of a magnet metaphor, may help to fill the needs of this creativity technique. A ‘time-machine’ feature, that could be implemented in the software, would be apropiate as well.
6. RESULTS

Design observations are considered useless unless accompanied by an analysis and a discussion (Bergström, 2009). Therefore, this chapter collects the most significant results that arise from the use of the 5 senses of interaction method.

6.1. The method

The Pentagons analysis method worked in three levels:

1. In a first quick eye-capturing level, its graphic nature enables a fast comprehension of the communication needs of the creativity techniques, as well as the features of the technologies, and how suitable are to each other (technologies and techniques).
2. In a secondary, more exploratory level, the differences between ‘coupled’ pentagons give us information about how creativity techniques may be modified in order to perform them distributed in a more efficient way, and on the other hand, we can identify the drawbacks and possible improvements of the given technology.
3. In a third level, when creativity techniques requirements are high, like in the case of Evaluation of classical brainstorming by a team, pentagons can be combined. That can lead us to come upon new technologies that mix previous technologies features.

However, the method need to be accompanied by analytical observations to obtain valuable output.

6.2. Analyzing creativity techniques

It has been demonstrated that the sense requirements change significantly between creativity techniques. It seems difficult to trace some major patterns of resemblance between techniques of the same group, that is, “What is the problem” techniques, “How to solve the problem” techniques, and “Evaluation” techniques.

However, a new distinction can be made depending on its interaction requirements. Here are some guidelines:

High sense of presence requirement techniques: While performing these techniques, a high level of interaction between designers is required. Non-verbal cues like embodiment, eye contact and gazing, or pointing are paramount in order to discuss over design objects, perform bodystorming, or just explaining an idea. They usually have a high sense of time requirement as well, since interpersonal
interaction needs of a synchronous, non-delayed communication. Some of these
techniques are: Brainstorming (stage 4) and Evaluation of classical brainstorming
by a team (stages 2 and 3).

**High sense of sharing requirement techniques:** In these techniques, the main
interaction is between designers and design objects. Here we perform actions as
sketching, grouping, or voting. There is a lot of building in each other ideas and a
need of simultaneously modify design objects. (often concurrent-independent
manipulation). Some of these techniques are: Brainstorming (stages 4 and 5), Word
association (stage 3), and Evaluation of classical brainstorming by a team (stage 2).

**Low sense of time requirement techniques:** These techniques do not
necessarily require of a synchronous, co-located communication, unlike most of the creativity
techniques. Some of the usual actions performed on them are voting or private
creation. Its asynchronous nature does not prevent from achieving desired results.
It is the case of Word association, Brainwriting 6-3-5, or Evaluation of Classical
Brainstorming by all the Participants.

### 6.3. Analyzing tele-collaboration technologies

The analysis of tele-collaboration technologies has demonstrated that there is no
such thing as a perfect technology that covers every one of our interaction needs.
Still, there are some that try, like SID devices. Though there is still a lot of work to
do in this field, and they are expensive, large and time-consuming to set up (Robin
Wolff, 2005), these devices offers the closest experience to co-located meetings,
specially regarding the sense of presence and the sense of sharing.

However, there are other technologies that excel concerning some senses, without
necessary trying to achieve the full pentagon. That’s the case of ClearBoard-2,
which allows the integration of personal and shared workspace, using a really
simple principle, which is drawing on and talking through a glass board.

*Roomware* is another example of technology that offers one of the best sense
experience, in this case, regarding design object interaction. It affords private
creation, layered views, natural element grouping... everything integrated in a
software ubiquitously available in the environment. However, interpersonal
interaction (sense of presence) within remote collaborators is not well afforded.

### 6.4. The ‘coupling’

Like in any product development process, the product requirements depend on the
needs (Karl T. Ulrich, 1995), and in this case, the needs depend on the creativity
technique that we want to perform.

Since the pentagons showed that most of the creativity techniques don’t have a full
pentagon of interaction requirements, and that there is no such thing as a perfect
tele-collaboration technology, ‘coupling’ similar pentagonal shapes seemed to be a good starting point for an analysis.

In some cases, like in the *Word Association* - *Distributed designers outpost* couple, the pentagons matched almost perfectly. Performing a deeper analysis, it has been found out that actually *Designers outpost* affords most of the interaction requirements of *Word association*, such as creating a topic map using post-it’s, or having a certain information about designers activity. *Word association* seems an appropriate technique to bring distributed then.

Brainstorming proved to be difficult to match. A Brainstorming session is full of activity, between designers and between designers and design objects (Rawlinson, 1981), (Kelly, 2001), sharing the same workspace and, without time delays. It is difficult to find a suitable technology to match this requirements. The closest may be SiD environments, through they have still important limitations and need to be developed (Robin Wolff, 2005). Accordingly, Brainstorming seem to be a challenging creativity technique to bring distributed.

Sometimes, a technology with low sense features seemed to be more appropriate to use rather than a ‘full pentagon’ technology. That is the case of e-mail, which, thanks to its asynchronous nature, it can be useful to perform an *Evaluation by all the participants* in *Classical Brainstorming*.

In a special case, concerning the *Evaluation by a team of Classical Brainstorming*, non a single technology offered the right features, so it is proposed a combination of two technologies, which are *ClearBoard-2* and *Roomware* in this case. Each one excel in a different sense, and the idea of integrating both in the same device doesn’t seem so unrealistic. That can give some useful input for future work.
7. CONCLUSION AND FUTURE WORK

The main goal of this thesis was to come up with a reliable method to study creative sessions. On response, the interactions that occur in these sessions have been categorized in 5 senses, namely sense of presence, sense of space, sense of time, sense of sharing and sense of naturalness. Each of these senses have been quantified in 5 levels (except sense of naturalness, in 3), and represented in pentagons, matching its 5 vertex. Then several creativity techniques have been analyzed with this method.

The method has proved to be able to synthesize group interaction in a creative meeting. The graphic nature of the pentagons helps to understand in a fast, eye-catching way, the requirements of a given technique.

Relevant conclusions have arisen from the comparisons between creative techniques: some techniques have the higher sense requirement, some have the lowest, some focus on a particular sense, etc. This has proved one of our hypothesis, which was to find out if different techniques have different interaction needs. The old categorization between creativity techniques, that is “What is the problem”, “How to solve the problem” and “Evaluation”, appear to be unrelated to the interaction needs. A new categorization may arise from the study of the senses of these techniques, based on the idiosyncrasy of group interaction.

The ‘coupling’ between techniques and tele-collaboration technologies has produced interesting information as well. The resemblance between the pentagon form of the technique and the pentagon form of the technology leads to a deeper study of the possibility of bringing the technique to a distributed level. In some cases, the deeper exploration confirmed what the pentagons announced in the first time (Word association- Distributed designers outpost). In others, a certain resemblance between the shapes lead to a deeper discussion about the ‘coupling’, regarding which elements of the technique should be changed in order to bring it to a distributed level, as well as what technique features should be improved (Classical Brainstorming- Videoconferencing/SID). Sometimes, two technology pentagons needed to be combined in order to satisfy the needs of a given technique. That causes a discussion where two technologies tried to be combine, with interesting results as well (Evaluation by a team – ClearBoard-2 + Roomware).

However, the method has proved not to be perfect as well. 5 categories with 5 levels appeared to be too constrained on occasion to describe creativity techniques, considering their chaotic nature, and the multiple ways that designers can interact. When describing technologies, sometimes they were insufficient to show all its features. Some of the characteristics that were left outside our scope were the possibility to visualize office documents, or recording results, and a deeper description of design objects manipulation (independent/co-dependent actions, sequence/concurrent manipulation, etc...).

Though hard and frustrating at times, the attempt to analyze a complex thing as group interaction in such a simple, seemingly naïve way, has been worth the effort.
Bergström states in his thesis: “only by exploring the complex can the novel be found, because it is here that the problems yet to be solved lives” (Bergström, 2009, p. 57). Personally I think that is only by studying group interaction from different points view, as uncommon as possible, we will be able to “think outside the box”, and ultimately, reach true innovation.

7.1 Future work

The pentagon method should be further applied and tested to reach a truly refinement. An extensive creative technique and tele-collaboration review may reveal the drawbacks (as well as the qualities) of the method. It was created by an iterative process, and this way it may be improved.

Concerning the analysis of creative meetings, we have seen that the needs of communication are related to the creativity technique being performed. However, we may ask ourselves, are the procedures of these techniques the most appropriate to reach creativity? And therefore, in which way group interaction should be constrained or encouraged in order to do that? We may find that some unexpected senses are paramount to obtain valuable creative results, while others are unnecessary or even harmful. Two more questions can arise from this approach: How tele-collaboration technologies should be designed in order to constraint some senses and emphasize others? And, may tele-collaboration technologies improve the performance on co-located meetings?

Performing the “coupling” between technologies and techniques has revealed possible suitable tele-collaboration technologies for certain procedures. Obviously, these assumptions need of real experimentation to be validated. Comparing the creativity results between a co-located and distributed meeting will be interesting as well.


Bailey, B. P. *A distributed display system for interactive sketching.* Department of computer sicence. Illinois: University of Illinois.


H. Clark, S. B. *Grounding in Communication.* In Baecker, R. M.


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<td>Designs consists of divergent and convergent phases (Bergström, 2009),</td>
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<td>(Banathy, 1996).</td>
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<td>Interaction with design objects in SID environments</td>
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APPENDIX 1: Co-located meetings scenarios

SCENARIO 1- Based on Luleå- Stanford design meetings during 2005/2006, supervised by Mattias Bergström and Peter Törlind (Matias Bergström, 2007)

Setup
For the first scenario we have some designers gathered in the same room. They have a table in the centre of the room, a white board on the wall and a pin board.

Sketching surface
Instead of using their own writing surface, a big sheet of paper has been displayed on top of the table, providing a shared sketching surface to the team members. The designers can use different sketching pointers as pens, markers, pencils, etc.

The topic of the session was written in the middle of the paper.

Allowed actions
First, the designers try to build their own ideas by drawing them on the sheet of paper. Then, they move around the table to see what the others have come up with. They interact with each other in a peer-to-peer communication and begin small discussions. Sometimes the discussion becomes the main discussion. They usually add to the existing concept or add an entirely new concept to the paper. They take turns in order to modify a given sketch, in a re-interpretive thinking cycle. It is not that easy, though, to draw on the same concept at the same time, due to physical limitations of the writing surface.

As they are located around a shared surface, they are permanently aware of each other, and, by using verbal, facial, or mimic expressions, they notice who wants to speak next, who wants to reply to a comment, who agrees or who disagrees.

Concerning the white board, it has been filled with product needs and specifications, but it is placed in the background and not really perceived by the team members. Nobody stands up to do any sketches on the white board.

<table>
<thead>
<tr>
<th>Setup</th>
<th>Co-located meeting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 designers gathering around a table</td>
</tr>
<tr>
<td>Sketching surface</td>
<td>A shared big sheet of paper</td>
</tr>
<tr>
<td></td>
<td>A white board</td>
</tr>
<tr>
<td>Allowed actions</td>
<td>Independent sketching and common sketching</td>
</tr>
<tr>
<td></td>
<td>Fluent verbal communication</td>
</tr>
</tbody>
</table>
The co-located design session. The team is sitting around the paper spread out on the table.

SCENARIO 2- Introducing the digital whiteboard, based on the paper “Encouraging contribution to Shared Sketches in Brainstorming Meetings” (Marcello Bastéa-Forte, 2007)

Setup

3 designers sit around a squared table, one in each side. The empty side is occupied by the “digital whiteboard”.

Sketching surface

Each designer is provided with a digital pc tablet. The devices run a networked sketching application, allowing each group member to easily view and add to the same shared sketching space, the digital whiteboard.

This sketching system was created with Java 5 run on Tablet PCs and a digital whiteboard. A sketching space is mirrored on all devices, so that a user’s drawing,
when sketched on their Tablet PC or on the whiteboard, is immediately visible to the rest of the group on their Tablet PCs and the whiteboard.

Each user’s cursor, identified with their name, appears in the shared view when they draw, select, or erase. They can also point out things in the sketching space with a gesture tool. The application provides tools for freehand sketching and erasing of varied line color and thickness and freeform selection to move strokes within the page.

The application supports multiple pages. Navigation between pages affects all displays, literally keeping the group “on the same page”.

Allowed actions

This system has, in fact, one unique shared surface, that can be sketched on by every single team member independently. This surface takes shape of a given number of Table PCs and a digital whiteboard. This means that, the team members are aware all the time of what the others are drawing.

This issue implies that, in practical terms, one single sketch is being draw at a time. There’s no private concept creation, but a constant built-in in a common concept. In terms of number of sketches, this is a negative situation, as was demonstrated by the experiment held by the authors of the paper.

The experiment, with the setup explained above, was done with several teams of 3 students. The experiment had two modes; one with the whiteboard and the tablet PCs as independent sketching surface, and a second mode with the whiteboard and the tablet PCs as a shared surface. The results of the experiment were that, while in the second mode the sketching contribution tended to be more balanced (each member drew a similar amount of strokes), the average total sketching was higher in the first mode. Some explanations that the authors of the paper give are:

1. More consciousness of how much each person contribute, and self-moderation as result
2. The participants felt an “implicit responsibility” for what they added to be a “real contribution”
3. The reduction of face-to-face communication, due to the constant looking to the individual tablet PCs

This higher awareness of quality contradicts the “go for quantity” tenet of brainstorming, and it has not been proved that it actually provides better concepts.

It also turned out that in the second mode the groups rarely approached the whiteboard. Some of the groups said that there was no point on using it directly, but it was useful for viewing and group focus. Others said that drawing on the whiteboard meant to “hold more power”.

Another output is that the Table PCs afford little real display space, especially if the team members wanted to keep a large number of sketches in view.

| Setup                      | • Co-located meeting |
### Sketching surface

- 3 designers gathering around a table
- Digital whiteboard and individual PCs tablets connected, forming an unique sketching surface

### Allowed actions

- Common simultaneous sketching
- Co-dependent actions
- Constant awareness of others drawing
- Private/individual sketching not allowed
- Difficult face-to-face communication
- Occasionally insufficient sketching surface

*Brainstorming co-located session using Tablet pc's (right picture) and digital whiteboard (left picture)*
APPENDIX 2: Creativity techniques review

Word association

- “What is the problem” technique
- Group
- **Objective:** Clarify the essence of a word or topic. It can help creating a common ground for future work
- **Preparation:** Previous research on the problem, by studying other companies’ products or related work, is recommended.
- **Duration:** 10 minutes

<table>
<thead>
<tr>
<th>STAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Write the topic in the middle of a whiteboard</td>
</tr>
<tr>
<td>2. Every participant use post-it’s to write words that can be associated to the topic, put them near the topic in the whiteboard</td>
</tr>
<tr>
<td>3. Votes are made for important topics to create a common understanding</td>
</tr>
</tbody>
</table>

Army of thousand (Brian Clegg, 1999)

- “What is the problem” and “How to solve the problem technique”
- Individual
- **Objective:** Approach the problem from a different perspective
- **Preparation:** None
- **Duration:** 15 minutes
STAGES

1. You have a thousand people at your disposal. They can have any expertise you like. You set them in solving the problem, what would they do? Write it down.

2. Now choose one of the solutions that you came up with and put the same army to implement it. How would they do it? Write it down.

3. Any ideas that are generated will need to be modified to fit your actual resources, but you may consider in the process new directions and points of view.

Classical brainstorming (Rawlinson, 1981)

- "What is the problem" and "How to solve the problem" technique
- Group
- Objective: Come up with as much ideas as possible, no matter how wild.
- Preparation: All the participants in a brainstorming session require to know some of the detail of the problem. Some participants will know the problem in great depth and others will just have a minimum amount of information, so they won't be inhibited in it.
- Duration: 2 hours
- SKETCHING

<table>
<thead>
<tr>
<th>STAGES</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. State the problem and discuss: Some of the participants may ask for more information about the problem</td>
<td>Turnover falling, and shops not as prosperous as they should be</td>
</tr>
</tbody>
</table>
2. Restate the problem – How to...: In this phase is being discussed ways to approach the problem in terms of “How to do something”. Each restatement including “How to” must make sense in a literal way, if not, it is a solution, and must be avoided at this phase.

<table>
<thead>
<tr>
<th>How to...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increase turnover</td>
</tr>
<tr>
<td>2. Reduce costs</td>
</tr>
<tr>
<td>3. Get more customers</td>
</tr>
<tr>
<td>4. Increase profits</td>
</tr>
<tr>
<td>5. Beat competitors</td>
</tr>
<tr>
<td>6. Sell more</td>
</tr>
<tr>
<td>7. Get people to buy more</td>
</tr>
<tr>
<td>8. Display better</td>
</tr>
</tbody>
</table>

3. Select a basic statement and write it down, ‘In how many ways can we...’: The next step is to select one or two of the restatements as a lead-in to the brainstorming sessions. A "leader" can decide which ones or it can be made by democratic commitment within the members of the group. Then one of the chosen restatements must be written down, in a new sheet of paper, with the words "In how many ways can me...". As ideas dry up on the first restatement, another one is taken.

<table>
<thead>
<tr>
<th>In how many ways can we get more customers and get them to buy more...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Advertise</td>
</tr>
<tr>
<td>2. Prices down</td>
</tr>
<tr>
<td>3. Specialize staff</td>
</tr>
<tr>
<td>4. Motivate staff</td>
</tr>
<tr>
<td>5. Train staff</td>
</tr>
<tr>
<td>6. Better display</td>
</tr>
<tr>
<td>7. Open later</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

4. Brainstorm: At this phase, the most important procedure is to keep the record of all the ideas and display them in the room so everybody can see them. They must be perceivable the whole time. The hints of a productive idea generation are explained in the chapter Brainstorming.

<table>
<thead>
<tr>
<th>Brainwriting 6-3-5 (Mycoted: Creativity and Innovation, Science and Technology)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• “How to solve the problem” technique</td>
</tr>
<tr>
<td>• Group</td>
</tr>
<tr>
<td>• Objective: Come up with a total of 108 ideas on the 6 worksheets.</td>
</tr>
</tbody>
</table>
**Preparation:** The name Brainwriting 6-3-5 comes from the process of having 6 people write 3 ideas in 5 minutes. Each person has a blank 6-3-5 worksheet (below).

**Duration:** 30 minutes

**SKETCHING** (Another modality of this technique, called **BrainSketching**, uses sketches, as well as written information, to represent new ideas)

---

**Problem Statement: How to...**

<table>
<thead>
<tr>
<th>Idea 1</th>
<th>Idea 2</th>
<th>Idea 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

**STAGES**

1. Everyone writes the problem statement at the top of his or her worksheet (word for word from an agreed problem definition).

2. They then write 3 ideas on the top row of the worksheet in 5 minutes in a complete and concise sentence (6-10 words).

3. At the end of 5 minutes (or when everyone has finished writing) pass the worksheet to the person on your right. You then add three more ideas.

4. The process continues until the worksheet is completed.

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**Visual Brainstorming** (Mycoted: Creativity and Innovation, Science and Technology)

- “How to solve the problem” and Evaluation technique
- **Individual/Group**
- **Objective:** To generate 20-30 basic idea-sketches on a specific problem in 1h
- **Preparation:** None
• **Duration:** 1 hour

• **SKETCHING**

**STAGES**

1. Each member of the team starts sketching ideas privately, just drawing whatever comes to their minds.

2. Present your ideas and sketches, trying to observe them with as much imagination as possible. Rotate the sketches, place images on images, cover top of bottom half... Write down all the ideas generated by this procedure in a different color.

3. Now cluster all the ideas together, place complex ones with simplistic ones, make comparisons... Write down the new ideas in a different color.

4. Go through the list of all the generated ideas, observe their evolution. This may inspire new directions of procedure.

**Evaluation of classical brainstorming** (Rawlinson, 1981)

• **Evaluation technique**

• **Group**

• **Objective:** At the end of the process, the evaluation team has three lists:
  1. Best ideas from the participants, i.e., those ideas with most votes
  2. The winners from the quick scrutiny of the lists by the evaluation team
  3. The best ideas from the evaluation team

• **Preparation:** The evaluation of ideas should be made by the participants of the previous brainstorming session

• **Duration:** 2 hours
Evaluation of ideas can be performed in two ways: an Evaluation by all the participants, and an Evaluation by a team made by few members of the brainstorming sessions, being deeply involved in solving the problem. The best scenario will be performing them both, in order to acquire a larger list of good ideas.

<table>
<thead>
<tr>
<th>EVALUATION BY ALL THE PARTICIPANTS</th>
<th>EVALUATION BY A TEAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All the ideas are wrote down, numbered, and given a copy of the sheet paper to all the participants</td>
<td>1. Each member of the team choose, without discussing them, the most brilliant ideas amongst the list</td>
</tr>
<tr>
<td>2. Each participant chooses about 10% of the ideas individually, by voting them</td>
<td>2. Each idea is grouped in a similarity group of not more than 40 ideas. Some ideas may belong to different groups</td>
</tr>
<tr>
<td>3. All the votes are collected by a “leader”, who makes a new list of the best ideas</td>
<td>3. They review all the groups according some criteria. E.g.: Cost, time to implement, feasibility... First, the criteria is applied negatively (E.g.: Idea number 129 cost too much), and then the rest is examined positively.</td>
</tr>
<tr>
<td>4. Having selected the best ideas, are arranged in a best ideas group</td>
<td>5. The criteria is again applied</td>
</tr>
</tbody>
</table>

The hundred dollar test (Creating Minds)

- **Evaluation technique**
- **Individual/Group**
- **Objective:** The notion of spending money grabs their attention and they are much more careful about deciding how to allocate it than allocating points. A focus on money also reminds people of the final goal of most creative and inventive activities: to make a profit and sustain the business.
- **Preparation:** None
- **Duration:** 10 minutes
STAGES

1. Assume you have $100 to spend on developing several ideas

2. Allocate your $100 across the ideas you are evaluating. It is your money, and you will get the profit generated from the ideas that get developed from your allocation. When a group of people is doing this, everyone spends $100 each across the ideas.

3. Look at how the money is spread out. A few ideas should be highlighted.

4. If the money has been spread too evenly, spend another $100, but assume you can only spend it in one lot of $50 and two lots of $25.

Six thinking hats (Edward de Bono)

- **Evaluation technique**
- **Group**
- **Objective:** Recommended when willing to use different kinds of thinking, and to explore ideas when selecting which to take forward (see other's reaction as well).
- **Preparation:** Explain to the team the meaning of the hats below. If people are not used to them, give a sheet of paper each with the colors and explanations clearly displayed on them. It can be a good idea to have a little bit of practice first, to help people get used to the idea and how to use them. The number of ideas at this point should be reduced to a short list.
- **Duration:** 30 min-1hour

<table>
<thead>
<tr>
<th>Hat</th>
<th>Headline</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Information</td>
<td>Asking for information from others</td>
</tr>
<tr>
<td>Black</td>
<td>Judgment</td>
<td>Playing devil’s advocate. Explaining why something won’t work.</td>
</tr>
<tr>
<td>Green</td>
<td>Creativity</td>
<td>Offering possibilities, ideas.</td>
</tr>
<tr>
<td>Color</td>
<td>Style</td>
<td>Explanation</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Red</td>
<td>Intuition</td>
<td>Explaining hunches, feelings, gut senses.</td>
</tr>
<tr>
<td>Yellow</td>
<td>Optimism</td>
<td>Being positive, enthusiastic, supportive.</td>
</tr>
<tr>
<td>Blue</td>
<td>Thinking</td>
<td>Using rationalism, logic, intellect</td>
</tr>
</tbody>
</table>

**PROCEDURE:**

In conversation, people now precede a comment that is using one of the six thinking styles by mentioning the hat, or even the color. For example, you could say, 'With the White Hat on, I'd like to ask if anyone else knows about this' (and in doing so, be forgiven for not being totally expert in all things).

If you are the leader or facilitator, add to the legitimization by using the hats yourself. Model behavior for others by regularly using all hats. Don't over-do it by using them in every sentence, but do model early and at regular intervals.

**EXAMPLES:**

- 'With my Green hat on, I'd say we should all flap our wings and zoom around the building with our eyes shut.'
- 'Feeling a bit Red here: I'm getting twitchy about doing this now.'
- 'With a Black hat, I'd say that we could not afford to do that.'
- 'Blue calling: The whole contraption is too heavy. It will sink without trace.'
- 'White hat says I can’t decide yet, I need to find out more. Any ideas?'
APPENDIX 3: Tele-collaboration technologies review

The Teamwork-station and the Clear Board, by Hiroshi Ishii, Minoru Kobayashi, and Kazuho Arita (Hiroshi Ishii, 1994)

Hiroshi Ishii and their team have been working on CSCW applications since 1988, focusing on the study of shared drawing space in the Media Space environment. They have developed and tested several collaborative work systems since then, including The Team Work-Station 1 and 2 and ClearBoard 0, 1 and 2. The aim of their research is to find an interface that enables seamlessness in two levels: seamlessness (continuity) with existing work practices, that is, allow users to work with their acquired skills, not having to learn a new protocol, and seamlessness (smooth transition) between functional spaces, integrating interpersonal space and shared workspace. We are going to review Team Work-Station 2 and ClearBoard 2, since they are improved systems from the previous models, and they primarily offer a sketching shared workspace.

The system architecture of the Team Work-Station 2 is based in two charge coupled device (CCD) video cameras are provided at each workstation: one for capturing live face images of the group member, and the other for capturing the hand gestures on each workspace. The software was developed for Mac computers. The key design idea of TWS-2 is a “translucent overlay” of individual workspace images, combining them in a shared screen and allowing the users to point and draw on the overlaid images simultaneously. Each user is provided with a headphone-microphone device as well.
The key metaphor of ClearBoard design is “talking through and drawing on a big transparent glass board”. ClearBoard-0 consists of a glass board positioned between the partners, and the following prototypes, as ClearBoard-2, try to bring this easy concept to a distributed level, by using a system architecture called “drafter mirror” architecture, illustrated in the image displayed below. Basically, the major improvement from TWS is the seamless integration of interpersonal space and shared workspace by displaying partner’s image in the background of the desktop, allowing users to easily shift between interpersonal space and shared workspace using familiar everyday cues such as the partner’s gestures, head movements, eye contact, and gaze direction. In addition, ClearBoard-2 uses “TeamPaint”, a multiuser computer-based paint editor, for shared drawing. It includes recording of working results, easy manipulation of marks, and layers for each user. Each user can only modify his or her layers by default.

System architecture of Team Work-Station 2 prototype

Design session via TeamWorkstation-2  Calligraphy lesson via TeamWorkStation-2
Roomware (Thorsten Prante, 2004)

Roomware is the name used to refer a virtual work environment developed by the research group of the Concert division at Fraunhofer. The main feature of this Cooperative Building is that computers disappear as a device but its functionality is ubiquitously available via new forms of interaction. Architectural elements like chairs and walls become information and communication devices.

Roomware consists of several devices, such as the Dyna Wall, the InteracTable, the CommChair, and the ConncTable. They are all touch- and pen-sensitive, and connected to each other via wireless. Every device, according to its physical properties, is suitable for a certain kind of work collaboration. Dyna Wall can work...
as a common shared surface to display results and global ideas. CommChair allows
great mobility around the room, being able to share and modify information from
the DynaWall in a tight collaboration situation. ConnecTables are modular versions
of the CommChair. Users can perform individual work on them or connect them to
another table (enlarging an interaction are for shared use) in a face-to-face
collaboration situation. The InteractTable is a wide display that allows individual
work as well as collaborative, since users on two or more sides can work on two or
more active synchronized views of the same document.

The software integrated on these elements, which allows the creation and
exchange of information, is called Beach. These are its main features, concerning
tele-collaboration:

- **Active synchronized working state, information and views:** Beach
  supports true synchronous sharing by providing concurrent access to
  information objects, such as workspaces or a single meeting document.
  It also allows a synchronized-scaled view of all displays, and the
  possibility to bring up private workspaces to a public level or send them
to any other device.
- **Local tools:** Tools such as Beach document browsers, room views, and
toolbars are local components, not necessarily shared among users.
- **Creativity tools:** Beach also supports some information sharing tools
  such as MagNets, which work as a magnet metaphor to support
  successive bottom-up structuring ideas; BeachMap, which gives users
  notation forms suitable to top-down information structuring in a deeper
  hierarchical structure than Magnets, and PalmBeach, that supports
  asynchronous idea generation and preliminary structuring using
  personal digital assistants.

To evaluate the qualities of a RoomWare distributed collaboration, we will study a
scenario with 2 or more teams working in 2 or more different RoomWares in
different locations. In these rooms, users can use devices as the CommChairs or the
ConnecTables for independent work, and the Dyna Wall as a shared surface with
the other teams

*The distributed designers outpost* (Katherine M. Everitt, 2003)

Distributed Designers’ Outpost is a remote collaboration system, based on a
collaborative web site design tool that employs physical Post-it notes as interaction
primitives. Users create new objects by writing on Post-it notes and adding them to
an electronic whiteboard, and organize information by physically moving Post-it
notes around on the board. A rear camera mounted inside the board captures the
location of notes, detecting when notes are added, remove, or moved. A front
camera captures the contents of the physical notes. Objects that are physical in one
space are electronic in the other space, and vice-versa. This way, distributed
collaborators can share a digital surface to post ideas, and relate them, using a
digital pen.
A mechanism called transient ink is available as well, which marks the board while using the pen, without permanently cluttering the workspace. The stroke is displayed in both boards for a few seconds, and then fades away.

Another awareness mechanism consists on displaying designers shadow on the board, by extending the rear camera’s vision processing. This shadow conveys the remote users’ presence, gesture and location in a lightweight fashion.

Users edit capabilities within remote collaborators extend to deleting the electronic image of Post-It notes. Then a red shadow appears on the physical note screen to indicate that it is no longer an information handle to the virtual remote analogue.

**Collaborative immersive Virtual Reality (Robin Wolff, 2005)**

In the VR (Virtual Reality) field there exist two primary classes of immersive displays: head mounded displays (HMD) and spatially immersive display (SID). They provide the user the feeling of being inside a 3D environment.

HMD often just offer tracking of the head and dominant hand, usually allowing a low field of view that has been associated with motion sickness and reduction in the feeling of presence. The other class of immersive displays is the one that spatially surround the user with fixed screens, based on the CAVETM (C. Cruz-Neira, 1993) principle.

The user is aware of his own body movement in relation to the environment through linked senses of vision, proprioception (the feeling of one’s body state), and sometimes haptics. Concerning collaboration, SID interfaces enables the communication of important cues such as referencing, gestures or proxemics. Further, natural body movement may be used to walk around an object, move the body and head to examine it from every angle, manipulate it with the hand and
interact naturally with remote users. It has been shown that within a tracked, stereo, real-time environment, a user’s ability to comprehend large-scale data is substantially improved. However, the required mobility and accuracy when manipulating objects makes it difficult to capture live video of collaborators and mapping this into a dynamic 3D environment in real-time without disturbing the interaction itself.

Object creation is usually not allowed or present serious difficulties, so these devices work primarily with already created objects.
## Features’ chart

<table>
<thead>
<tr>
<th>Name</th>
<th>Team Work-Station</th>
<th>Clear Board 2</th>
<th>Roomware</th>
<th>The distributed designers outpost</th>
<th>SID environments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of teams</td>
<td>2-4</td>
<td>2</td>
<td>1+</td>
<td>2</td>
<td>1+</td>
</tr>
<tr>
<td>Number of users/team</td>
<td>1</td>
<td>1</td>
<td>1+</td>
<td>1+</td>
<td>1+</td>
</tr>
<tr>
<td>Medium</td>
<td>Co-located</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Distributed</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Communication mechanisms</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Verbal communication</td>
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<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye contact/gazing</td>
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<tr>
<td></td>
<td>Co-dependent actions</td>
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<td></td>
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<tr>
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<td>Shared workspace</td>
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<td>Single touch surface</td>
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<td>Ergonomic features</td>
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<tr>
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<td></td>
<td>Instantly recordable</td>
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</tbody>
</table>