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# Adaptability of collaborative design within an augmented space

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*This paper presents a research on the reuse of a collaborative design scenario with a co-presence of a situation of collaboration at a distance. Our interrogations are about the adaptability of activities of collaborative design at a distance within augmented spaces sheltering specific situations. Our objective is to observe the influence of space components variability on the activity and conceivers' exchange quality. The paper presents the established method, the obtained data and the observations developed from the analysis of initial and adapted situations. With reference to our analysis, it displays the evolution of design practices, in the field of design and architecture, from constraints, means and work devices standpoints. We refer as well to the impact of ICT (Information and Communications Technology) insertion on the way of exchange between collaborators.*

Keywords: collaborative design, augmented space, collaboration at a distance, reuse, digital devices

## 1 Introduction

The context of conception in the field of architecture and design is continuously evolving, relatively to external constraints, including the problem of innovation [18]. Competitiveness, very short deadlines, and increasingly coercive exigencies require the association of the interdisciplinary competences for the conception and the execution of a project [12] [6].

These competences are often put at the stake simultaneously in order to respond quite quickly, to the market requirements and exigencies [5]. The set of these parameters puts forward the complexity of the design activity that requires collaboration on the level of means and work devices. The classical tools of design (paper, pencil and mock-up) have witnessed an evolution through computer skills (computer aided drawing). This digital integration has altered the global process of design activities [8].

Information and communication technology as well as the need for mobility led to different forms of work spaces, transforming the traditional workplace into a digital one [14]. Through this technological transformation, enterprises have witnessed changes in their practices [10]. This insertion of the digital technologies generates everyday new perspectives and re-organise the functioning of teams. It keeps progressing and influencing the way of exchange between the different collaborators of a project. Besides, we notice new practices within agencies (designers, architects and engineers), tinkering digital supports to perform computer-aided conception activities that turn out to become increasingly collective and multidisciplinary [2].

The meeting in a co-presence being in the centre of these practices (referring to the dichotomy space/time matrix by Johansen [15] then enhanced by Ellis, Gibbs and Rein [11] in the field of CSCW<sup>1</sup>), we study in this paper the reuse of the metaphor of this collaboration in co-presence in the context of a situation of

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<sup>1</sup> Computer-Supported Cooperative Work

collaborative design at a distance.

Thus, an innovating device of synchronous sharing of annotation is made available for conception practices, within a pedagogic context, in order to respond better to the fundamental requirements of the collaboration.

The collaborative conception in co-presence is performed mainly through the employment of different procedures of communication (verbal, non-verbal, written, graphic etc.) [1], we inquire about the impact of the reuse of these situations in co-presence on the way our conceiver collaborate. So our research issue is about: how can we make these practices reusable and adaptable within a distance collaboration context?

For that, we present in this paper, firstly, the context of research. Then we refer to the method of collecting the established data according to an experimental well-defined procedure. Considering the co-presence activity as a reference situation, we display, later, the situations of distance collaborative design, observed as well as data processing. Eventually, we present the results put forward according to our qualitative data analysis.

## **2 Research context**

The situation studied in this research context occurs in augmented spaces, equipped with a system favouring synchronous collaboration at distance. This collaboration thus takes place in two different, distant workplaces connected virtually through an innovating system (Figure 1) developed in LUCID lab of the University of Liege [19].

Labelled CDS “Collaborative Digital Studio”, this space integrates three elements to allow the verbal and graphic collaboration at distance. The first element is a videoconference screen, favouring the audible and visual communication necessary to the oral and social exchanges. The second is a means of communication through drawing by a digital surface that allows the interaction of users thanks to an electronic pen. The third is SketSha<sup>2</sup> software that allows the creation, the sharing and the manipulation of all documents (blueprints, photos, sketches...) in real time, at distance and with both hands via internet, as well as annotating, composing and adjusting this content into graphics (Figure 2)

Based on the metaphor of co-presence meeting, this multimodal augmented space of work has contributed to the appearance of a new way to deal with the collaborative design activity. It is also at the origin of the emergence of new spatial experiences [13]). And here lies the issue of the research, emphasizing more specifically, these spatial experiences and the implication of these new tools on the conceivers work space.

The integration of this technology within the collective activity led us to consider the notion of distributed cognition in order to evaluate the interaction of a social group while performing a conception activity at a distance [7].

The technology deployed here, presents an interface favouring online social exchanges. It allows the communication between different persons being in dispersed personal workspaces departing from a common workspace. The interface becomes more complex as workspaces double [18]. We depart then from the assumption that the space suggests and conditions user’s action, given that space components generate mental representations that act on the user’s behaviour [14]. Each situation is, in fact, interpreted through thoughts that may be stimulated by the space where the user sets his place and fits up his behaviour.

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<sup>2</sup> SketSha: Software developed in LUCID lab, Ulg, it enables the users to share, at a distance the same workspace and allows a group of collaborators to work on the same digital surface with an electronic pen. It displays different types and colours of pens for the collaborators to annotate shared documents [22].



Figure 1 Collaborative Digital Studio

The introduction of these graphic technologies in collaboration at a distance, relatively to co-presence, enables us to question the relationship between the users and design tools from adaptability and accessibility standpoints. But also it calls out the connection between the digital and the work space itself. We raise then the question about the initial usage scenario, reused in an adapted one. As well we enquire about the influence of the co-presence situation (considered as a reference) reused in a distance situation in the collaborative design activity.

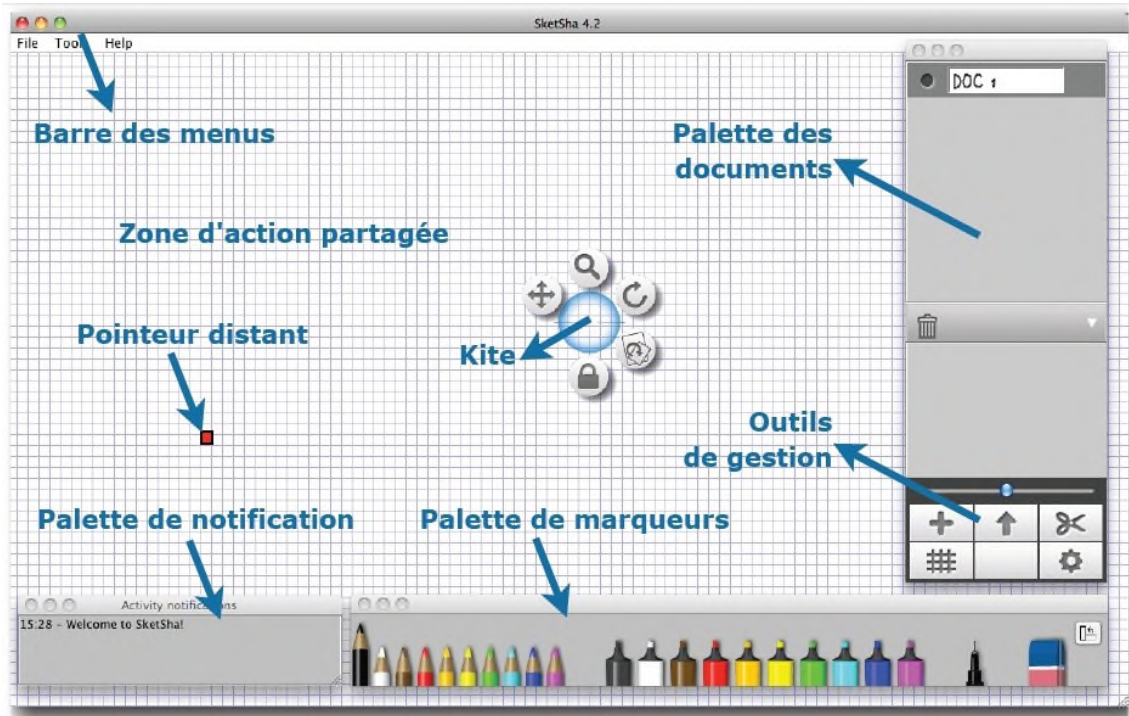


Figure 2 SketSha software interface [22]

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influence of the co-presence situation (considered as a reference) reused in a distance situation in the collaborative design activity.

## **2 Research Method**

The immersion of information and communication technologies in the workspace creates for many users, devices enabling the connection of spaces geographically separated. This collective work at a distance includes teleconference and software sharing screens or documents that allows the users to discuss or work at a distance on common tasks. The actors of the conception belong so far to “extended enterprises” [8]. This advance generates augmented spaces that break the physical boundaries of real space through digital interfaces. Work tools became themselves virtual boundaries altering space and time relationship: “we move from a spatial concept to temporal concept where the distant becomes close which leads to the flattening of the distance and the space” [14].

Through the digital device provided by these TIC, the user finds himself in an augmented space which is real and virtual at the same time. Thus we notice the paradoxical development of a visibility and at the same time, the devices invisibility [17]. The organization of work from a distance has changed the configuration of the workspace, by creating a different environment from interactions standpoint [4]. That’s why we are interested in the adaptability of distant environments in the collaborative design situations.

In this context, our research method is based on the qualitative observations of collaborative activities and then, enquiries are carried out about users. Accordingly two situations we’ll be studied, the first in co-presence, it serves as a reference situation for the second, a distance one, here we try to understand the influence of the latter on the procedures of conception exchange.

The studied situations took place in two higher education environments: one at the Higher School of Design Sciences and Technologies of Tunis (Tunisia) and another at the Faculty of Applied Sciences University of Liege (Belgium). They are focused on collaborative conception meetings or projects revue, carried out in the three following skills: design, architecture and engineering. Our aim is to extract the important parameters in real and augmented situations, altering at each time a particular variable that will be précised later.

In this scope, we have studied the quality of exchanges and interaction between users during several sessions of collaborative work. We have observed the conceivers in their spatial environment, their interactions with the real and virtual space and with each other.

We have set at first, situations of collaborative work in co-presence. The observation of these experiences has allowed us to analyse the type of interaction about the space, its components and organization on the collaborative conception activity. This has enabled us to extract observable and questionable variables. (cf. 1 reference situation)

The co-presence situations are, thus, our first field of observation that will enable us to develop the one at a distance. They have supplied us with the data about co-presence collaboration practices that in their turn will enable us to deal with the analysis of distance-collaborative design activities experiment. This is how we have updated the three variables: adjustable, observable, and questionable in order to study collaborative design situation at a distance. (cf.2 similar situation)

We consider in our survey, that the adjustable variables are those that we have altered during different situations of the experiment. They involve the real and virtual space. By altering these variables we aim at the analysis of conceivers interactions with the space in group work situations.



*Figure 3 Real workspace, non-equipped space (co-presence)*

As far as observable variables are concerned, we have opted for observing the collected data during the experiment. Our aim is to draw attention to the variables that influence the collaborative design activity (co-presence, distance) as related to real and virtual space.

As for the questionable variables they are the variables through which we have drawn up our questionnaires. Questions are related to the participants' experiences during the collaborative conception session. Our objective is, then, to gather the conceivers' personal data considering that; this data can't be observed. The analysis of the questionable variables enables us to complete and assert the analysis of the observable variables.

In the context of this paper, we mention some examples of these three different variables later.

### **3 Research Procedure**

#### **3.1 Reference situation: co-presence collaborative design**

##### **3.1.1 Context**

Co-presence situations involve collaborative design non-equipped activities. The space that sheltered these situations is lacking in all technological tools.

We have observed fourteen participants, split up and placed into three different classrooms (Figure 3). The experiment took place in two work sessions.

The situations happen during project sessions of design degree at the Higher School of Design Sciences and Technologies of Tunis. (TN)

##### **3.1.2 Implementation**

The development of these experiments is performed from two types of adjustable variables; the first are related to the components of the interior space and the second are related to space organization.

Let's present examples from each type, illustrated through figures to explain the objective of these variables.

#### **Space components:**

##### *The clutter of work surface*

This variable involves the change of work surface dimensions regarding to the same numbers of participants.

We alter the dimensions of work surface clutter. The participants work on a larger surface in a second situation; this is what increases the distance between the collaborators who sit opposite to each other.

#### **Space organization:**

##### *Work surface layout*

This variable involves the modification of the work surface layout regarding the limits of the interior space.

In a first situation, we place the work surface at the centre of a spatial envelope, which leads to the possibility, for the participants to have circulation space all around. Then we alter the work surface proximately toward the outer edge, in a way that we reduce the circulation zone around the work surface.

##### *Participants' placement*

The objective of this variable is to alter participants' position as relating to each other. At first, the participants are seated opposite to each other in pairs. Then, in a second situation, we alter their position by placing two participants perpendicularly to the two others.

### 3.1.3 Collected data

We have observed six work sessions each of six hours. We have then totalized for the co-presence situations thirty-six hours of observation. We have chosen the continuous passive observation as a gathering data method. We have collected notes and videos without intervening on the field. The data was gathered through direct observation of the conception activities. The data is gathered in three types: videos, notes and questionnaires.

We have shot all the sessions in order to observe in a detailed way the participants' behaviours regarding their work surface and real spatial environment.

The videos were recorded from two opposite view angles that enables us to observe all participants activities. Considering that in this type of situation the conceivers can invest the interior space as a whole. They can move the work surface around.

We also took notes that seemed pertinent at that moment. Questionnaires were meant to complete our observations in order to extract from them a feedback about the users' experience.

### 3.1.4 Variables highlighted by the analysis

We have performed, firstly, a qualitative analysis. Based on questionnaires filled in by the users and by the video corpus analysis, we have also performed, then, a quantitative study relative to the different variables clarified hereafter.

We have dealt with five types of *observable variables* relating to the space, the behaviour, the types of exchange and the activities. This division is inspired by the study of actors' behaviour in Gero conception process quoted by [3].

Let's present an example from each type of variables.

As far as the *ambiance* is concerned, we observe natural daylight, what we are interested in, precisely, is the luminosity and the direction of lighting as related to the work surface and regarding the participants.

For the *space*, we observe two variables: the first involves the physical position of the participant regarding the work surface and the second involves the participants' position regarding each other.

About the *behaviour*, we have chosen to observe motion: we have picked up three types of movement that the participants make during the design activity. We have also focused on the posture adapted by the participants adopt (sitting- bending-standing)

Concerning *information exchange*, we have observed two types of exchange: speaking and annotating. We have measured the time of participants' interventions when they talk and when they communicate through annotation during the conception.

We have pointed some *types of activities*, which are performed during the collaborative conception, such as the nature of intervention whether it is oral or graphic or as well the interruption of tasks.

We have also defined the questionnaires according to six types of variables, with regard to the participants' experiences during the collaborative conception session, from standpoints of the spatial environment components quality, collaborators' numbers, communication, accessibility, emotion, motivation and group. Let's present some examples of these variables:

Regarding the *quality* of *ambiance*, we have raised questions that help us estimate the quality of the natural and artificial lighting for the participant, with regard to the work surface.

We have raised questions about the *participants' number*, what we are concerned with, is mainly the participant's appreciation regarding the session objective.

We are, as well, trying to evaluate, the total number of the collaborators within the same real space regarding the work surface.

We also ask the participants about the fluency of *communication*: we try to know about the participant appreciation of the nature of exchange between the different collaborators.

We interrogate the participants about their viewpoints concerning the work surface *accessibility* and the drawing materials.

Regarding *emotion* and *motivation*, we seek to estimate the participants' satisfaction about coordination tasks, but also their personal satisfaction about the efficiency of its contribution in the conception.

As for the *group*, participants are requested to provide us with a feedback about how confident they felt about the members of the group, during the collaboration. We ask them as well about the quality of tasks executed by the group.

We present in Table 1 all adjustable, observable and questionable variables that enables us to implement the experiences concerning collaborative and co-presence design situations.

Table 1 Adjustable, observable and questionable variables

<i>AJUSTABLE</i>	<i>OBSERVABLE</i>	<i>QUESTIONABLE</i>
<p><b>- Space components</b>                      V.M1 work surface clutter                      V.M2 Spatial configuration  <b>- Space Organization</b>                      V.M5 Clutter                      V.M6 Work space layout.                      V.M7 Occupants' number                      V.M8 Participants' placement.</p>	<p><b>-Ambiance</b>                      V.O1 Natural lighting.                      V.O2 artificial lighting.</p> <p><b>-Space</b>                      V.O3 Participant – work surface.                      V.O4 Participant - Participant</p> <p><b>-Behaviour</b>                      V.O5 Motion activity.                      V.O6 Posture.                      V.O7 Placement change.</p> <p><b>-Information exchange</b>                      V.O8 speech                      V.O9 Annotations</p> <p><b>-Activities</b>                      V.O10 Types of activities.                      V.O11 Tasks interruption.                      V.O12 Time of intervention.</p>	<p><b>-Quality</b>                      V.Q1-2 natural and artificial lighting / work surface.</p> <p><b>-participants number</b>                      V.Q3 session objectives.                      V.Q4 work surface.</p> <p><b>-Communication</b>                      V.Q5 Conviviality                      V.Q6 communication fluency.</p> <p><b>-Accessibility</b>                      V.Q7 work surface.                      V.Q8 drawing material.</p> <p><b>- Motivation emotion :</b>                      V.Q9 Satisfaction                      V.Q10 Implication</p> <p><b>-Group</b>                      V.Q11 trust                      V.Q12 Session objective.                      V.Q13 Tasks quality.</p>

The sequence of collaborative and co-presence situations have also enabled us to notice the variables that should be kept unchanged and some others that are not studied. We have also noticed that there are variables that we don't grasp. That's why we have defined the variables as follows:

- *The fixed variables*: are the ones that could really vary, but that we have chosen not to change them, such as the artificial light. We opt for not changing the artificial lighting since we don't study the amount of lighting (lux number) in the interior space. We are rather interested in the natural lighting, but with reference to sun orientation, luminosity and beams direction regarding the participant and the work surface.
- *The uncontrolled variables*: are those that can't be studied as we have no means to study them. For instance, we can't afford to study variables relating to the thermal or acoustics.
- *Non-studied variables*: the ones that we opted not to study; such as the displacement of artefacts, as well as their content.

Thanks to this new division, we were able to study the similar target situation: the distance collaborative situation equipped by the CDS.



Figure 4 Virtual workspace, augmented space. Liege/Nancy



Figure 5 Peer To Peer / Virtual Desk [23]

#### 4.2 Implementation

The experiences undertaken in this augmented space enabled us to reuse the work situation of co-presence collaborative conception in the distant one. This space responds to the conditions required for verbal,

graphic and visual communication. It tends to assume the procedure on the verbal level (by audio), the graphic level (by shared drawing), and the visual level, such as eye-contact, and to some gestures (by video conferencing) [18].

The distance collaborative device is implemented in two forms.

The *Peer to Peer* (P2P) consists in graphic tablet of A3 format and videoconference screen. It can receive one or two users in each workspace. The graphic tablet is an integral part of the desk. The height of this desk can vary according to the user's need. It's a quite flexible device in the interior space; it can be carried and moved easily.

The *virtual desk* can receive a team of five persons, as it consists of an A0 format digital table, placed under a projection system. This device is considered as a stable element, fixed where the interior space is conceived according to this structure (Figure 5).

We observe through this second study of situations taking place in a real and virtual space at once. This situation includes some other types of variables to be manipulated, observed and questioned: they are the variables relative to the experimental device, the digital tool and the virtual space.

- *Relative to device*: This variable involves the modification of device on which the participants work. In a first situation, participants collaborate on a P2P and then, they work on the virtual desk. We are concerned with the modification of the space clutter of the work surface in this experience.
- *Relative to participants' placement*: In both situations, the participants work on the same device (P2P). In the first situation, the collaborators from both sides observe the virtual work surface as if they were really next to each other, regarding the artefact. In the second situation, we alter the direction with regard to the work surface, in a way that the collaborators observe the interface as if they were really facing each other.

### 4.3 Collected data

We have observed nineteen sessions involving distance collaboration, each lasts thirty minutes. We have shot all sessions which enabled us to observe in a detailed way the participants' actions as far as the real and virtual space components are concerned. This led us to an acute observation of all types of exchange whether verbal, visual or gestural.

For the augmented space, we resorted to four integrated cameras gave us access to one quadric-form video (Figure 6). This kind of collected data is different from the one of co-presence collaborative conception situation: it enabled us to view the overall activities of the participants, from four *view angles* at once. A fifth non-integrated camera provides us with an overall view of the interior space where the collaborative conception activity is performed.

We've been also present in all distance collaborative situations as observer (at Liege University). Our presence enables us to gather data through notes and questionnaires.

### 4.4 Variables highlighted through the analysis

In the distance collaboration situations, we have set new observable and questionable variables involving augmented space and work device. We define as follows some types of variables:

#### Observable

We have observed a variable relative to the space, which is the visibility of the participants for distant contributors.



Other variables have been observed which are rather relative to activities such as the way pen is held. We have measured the time spent by the participant while holding the tool that enabled him to interact by annotating on the device. We have observed also the types of mistakes made by the participant while using the device.

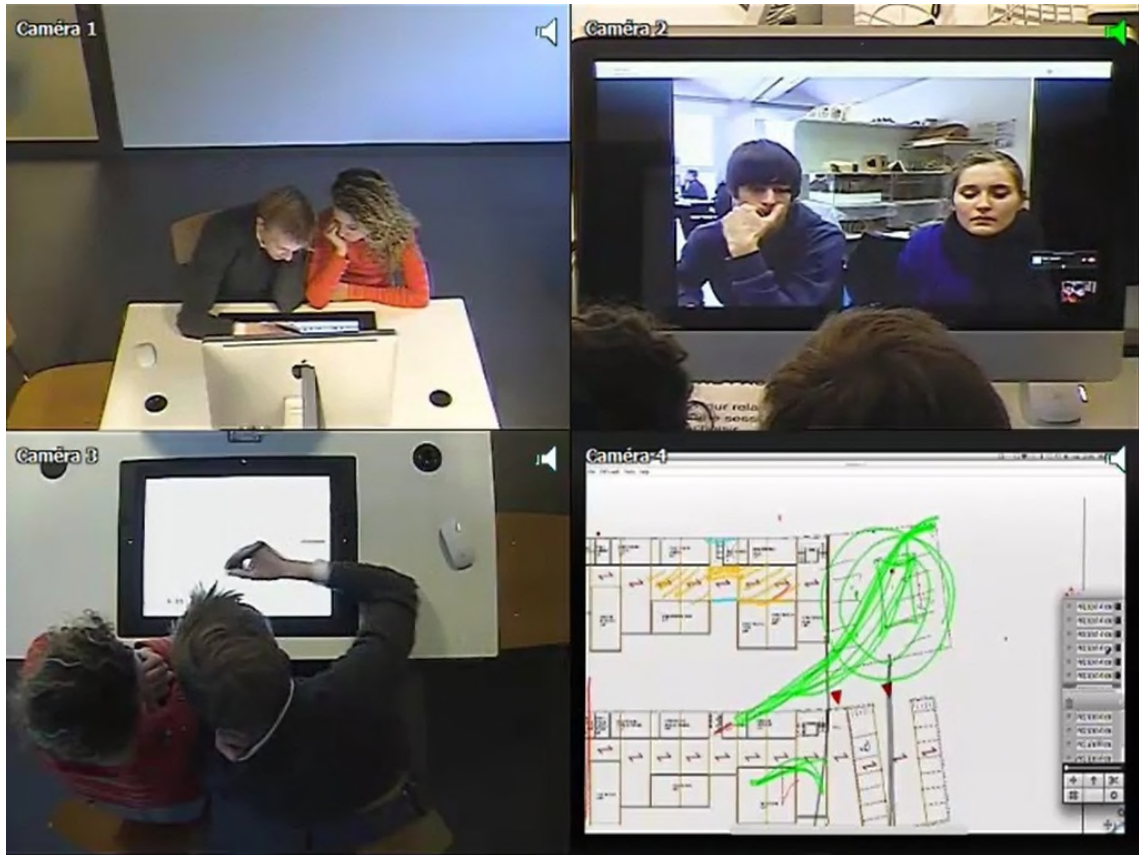


Figure 6 Quadric of observation device

### Observable

We have observed a variable relative to the space, which is the visibility of the participants for distant contributors. Other variables have been observed which are rather relative to activities such as the way pen is held. We have measured the time spent by the participant while holding the tool that enabled him to interact by annotating on the device. We have observed also the types of mistakes made by the participant while using the device.

### Questionable

We interrogate the participants about variables relative to the quality, such as sound. What we are concerned with is quality appreciation of the videoconference sound. We are also interested in the viewpoint of the

participant about the digital work surface quality, from contrast and luminosity standpoints. And we ask the collaborators about the quality of the picture received through the videoconference screen.

As for the variables relative to accessibility, we interrogate the participants about the digital work surface, with regard to work tools and electronic pen. We ask them also about trust, regarding the digital device use. We present hereafter (Table 2) the evolution of variables that enabled us to implement and analyse the collaborative conception situations, relatively to the situations of reference.

Table2 Evolution of variables

<i>AJUSTABLE</i>	<i>OBSERVABLE</i>	<i>QUESTIONABLE</i>
<b>- Space components</b> V.M1 Work surface clutter. V.M2 Spatial Configuration <u>V.M3 Device</u> <u>V.M4 number of virtual spaces</u>	<b>-Ambiance</b> V.O1 natural lighting.  <b>- Space</b> V.O3 Participant –work surface. V.O4 Participant – Participant <u>V.O13 collaborators visibility</u>	<b>- Quality</b> V.Q1 natural lighting - work surface. <u>V.Q 14 sound</u> <u>V.Q 15 work surface visibility</u> <u>V.Q 16 videoconference</u>
<b>- Space organisation</b> V.M5 clutter. V.M6 occupants ‘number V.M7 participants’ placement.	<b>- Behaviour</b> V.O5 Motion activity. V.O6 Posture. V.O7 placement change.	<b>- participants number</b> V.Q3 session objective. V.Q4 work surface.
<b>Un-manipulated variables</b>	<b>- Information exchange</b> V.O8 Speech V.O9 Annotations	<b>- Communication</b> V.Q5 Conviviality V.Q6 Communication fluency.
V.F artificial lighting.	<b>- Accessibility.</b> V.Q7 work surface. V.Q8 Drawing material. V.Q 17 Digital work surface <u>V.Q 18 Pen</u>	<b>- motivation emotion :</b> V.Q9 Satisfaction V.Q10 Implication <u>V.Q 19 tool regarding trust</u>
<b>Un-controlled variables</b>	<b>- Activities</b> V.O10 Types of activities. V.O11 tasks interruption. V.O12 time of intervention. <u>V.O13 pen holding</u> <u>V.O15 mistakes</u>	<b>- Group</b> V.Q11 trust V.Q12 session objective. V.Q13 tasks qualities.
<b>Non-studied variables</b>		
V.NS1 artefacts content V.NS2 artefacts displacement		

## 5 First observations

This collected data, based on different collaborative conception situations, have enabled us to evaluate the quality of exchange between collaborators of meetings reused in a work context, retaining the co-presence meetings as reference situation.

Therefore we had to define a method that allows us to put into practice the set of variables relative to user, the tools he uses to collaborate with others and the environment in which a group evolves and works collectively at a distance.

We have brought out some constraints generated by the distance work tool, regarding verbal and graphic interventions. We have observed that within a co-presence situation the conceivers have their own tool of

work (paper, pen. etc.) unlike in distance situation, where the work device becomes the common space. They find themselves working with an electronic pen which, according to our observation, prevents them from intervening (graphically) spontaneously. We could even see several situations where the conceivers abstain from intervening not to bother the one who manipulate the pen.

While we have observed that, during the conception situation within augmented space the collaborators kept still in their places as the mutual visibility of the listeners becomes a constraint. Unlike the co-presence situation, where the conceivers invest all the space, they move, change places, turn around the work surface and still are visible by all collaborators.

We have also noticed that in the co-presence collaboration, the drawing material takes too much room on the work surface. This clutter generates several particular situations, including for instance: chairs (or other space components) serve as a stand for material, what kept conceivers standing up while working. Unlike the augmented space, where the digital interface allows the access to all documents easily, while being comfortably seated. However, being limited by the visual field of the videoconference, the users are restricted to share only documents via SketSha software. Other documents on which they think, annotate and execute their sketches are kept on the desk and can be only shared by redirecting the tool, trying to show them via the videoconference.

Starting from this first approach, we have also been able to draw out the influence of virtual tools positions (tracing paper or floating menus) and real tools (pens) – relative to different configuration of augmented real space – as well as collaborators' positions, tools accessibility, the techniques of virtual information projection, on real surfaces, upon the usage scenario.

## **6 Conclusion**

The objective of this ongoing survey is to observe the influence of the spatial environment on the nature of verbal, gestural and graphic exchanges, in situations where we reuse the co-presence collaborative activity in a synchronic collaboration from a distance.

This survey is meant to analyse the collaborative conception in the fields of design and architecture from a qualitative standpoint. This enabled us to observe the variables employed in both usage scenarios, the co-presence and the distant ones, such as verbal actions typologies (provide an opinion, justify a choice, and convince one's collaborator). However, other variables were not used in distance collaborative situations, such as graphic exchange, regarding intervention type, for instance, 'interaction at any time' or 'all together' on the artefact. Some other variables were transformed namely 'the surface holding by the conceivers' and 'the work space' as well as 'motion activities'.

We also aim at gathering information about the effect the characteristics of physical space, such as its spatial organization, on the communication quality (sound, image and artefact). This approach also allows us to set some first links between the components variability, the spatial environment and the exchanges quality in collaborative conception. This survey will be followed by a quantitative approach in order to analyse the clues of facts which will enable us to evaluate distance collaboration device as far as accessibility and usability are concerned.

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### **Aims and scope**

Today's design strongly seeks ways to change itself into a more competitive and innovative discipline taking advantage of the emerging advanced technologies as well as evolution of design research disciplines with their profound effects on emerging design theories, methods and techniques. A number of reform programmes have been initiated by national governments, research institutes, universities and design practices. Although the objectives of different reform programmes show many more differences than commonalities, they all agree that the adoption of advanced information, communication and knowledge technologies is a key enabler for achieving the long-term objectives of these programmes and thus providing the basis for a better, stronger and sustainable future for all design disciplines. The term sustainability - in its environmental usage - refers to the conservation of the natural environment and resources for future generations. The application of sustainability refers to approaches such as Green Design, Sustainable Architecture etc. The concept of sustainability in design has evolved over many years. In the early years, the focus was mainly on how to deal with the issue of increasingly scarce resources and on how to reduce the design impact on the natural environment. It is now recognized that "sustainable" or "green" approaches should take into account the so-called triple bottom line of economic viability, social responsibility and environmental impact. In other words: the sustainable solutions need to be socially equitable, economically viable and environmentally sound.

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