Time, Occurence and Switching

Appropriation of two tools in collaborative design
Point of view of aspectualization

Samia Ben Rajeb
Université Libre de Bruxelles
Brussels, Belgium
email: samia.ben.rajeb@ulb.ac.be

Shima Shirkhodaei
University of Liege
Liege, Belgium
shima.shirkhodaei@ulg.ac.be

Pierre Leclercq
University of Liege
Liege, Belgium
pierre.leclercq@ulg.ac.be

Abstract— **This article focuses on the modes of implementation of an innovative device, associating two tools to instrument distant and synchronic collaborative design. The paper presents results about the modes of implementation of an innovative device, which combines two tools, in order to instrument distant and synchronous collaborative design. On account of the fact that these tools differ essentially in terms of immersive and non-immersive work space, this research focuses initially on modes of switching, which are used in an immersive work space to a non-immersive work space. Our work questions the appropriation of the two tools by users, relying on looks, designs, but also the collective operations involved in the design process.**

Keywords- computer supported cooperative work; methodology of multi-modal user interfaces analysis; semiotics; cognitive ergonomics; case study of collaborative synchronic design platforms.

I. INTRODUCTION

The rapid evolution of operating technologies in the field of collaborative design raises not only the question of the singular use of each tool, but also the influence of their association in this activity and during the action. In this context, we present here an analysis of the modes of appropriation of an innovative device, associating two tools to instrument distant and synchronic collaborative design : the Hybrid Ideation Space (HIS), developed at the Hybridlab, a laboratory of University of Montreal [1][2], and the Sketch Sharing system (SketSha), developed at LUCID, a laboratory of University of Liege [3][4]. Both are based on the notation of graphic artifacts in real time. One (HIS) allows immersion in the interior of a virtual representation of a conceived space, the other (SketSha) makes it possible to share and act on 2D documents. In the experiment, these two tools were associated to allow two groups of student designers from University de Liege and School of Architecture of Nancy to collaborate, under the direction of the HybridLab team. Two questions emerge from this original experimental situation: the first concerns the singular implementation of each tool and the second concerns the degree of programmatic compatibility in the use of a device, which integrates various tools for exchange and synchronic collaboration. To answer these questions, Section II first describes the experimental protocol implemented in the simultaneous usage of these two tools. In Sections III and IV, we present the methodology of data analysis based on the notion of aspectuality (punctual, iterative, durative, inchoative and terminative), well known in the field of Greimasian Semiotics. This notion guides us to the definition of determining categories to explain the switching from one tool to the other during the collaborative activity.

Our approach focuses on the methodological aspect to enable the analysis of complex collective activities involving new technologies. This is why our state of art only concerns the methods and shows why we have resorted to aspectuality to address this kind of problem (see Section III).

Based on quantitative and qualitative analyses, Section V will show that the degree of familiarization of users with the new technologies is a determining factor to characterize the issues and the limits of this superposition of tools. Finally, we will also detail to what extent these two complementary devices can be articulated in order to support preliminary phases of architectural design.

II. FRAMEWORK AND RESEARCH QUESTIONS

This research is part of collaboration between the LUCID laboratory at the University of Liège and Hybridlab at the University of Montreal. Both HIS and SketSha devices, developed in in the universities of Liege (Belgium) and Montreal (Canada), were enabled to instrument collaborative design.

SketSha software enables real-time sharing of drawings and annotations, via a digital tablet horizontally placed in front of the designer, drawn by using an electronic pen during a remote meeting. Images, PDF, DXF drawings or other documents can be imported and made available to all partners of the project. These documents are shared on the basis of a stack of semi-transparent tracing paper that users can annotate, store, superimpose or manipulate in real time.

HIS is a device based on an immersive system for placing various remote users within their graphic representation, their sketched freehand drawings and three-dimensional models "on which they interact by manual and digital actions". This complex device mainly consists of two parts: (1) a digital tablet placed horizontally showing a 2D image of the project. The image is chosen by the designer and depicts the localization of the project intervention. This image allows drawing and annotation via an electronic pen; (2) a piece of canvas that is hung vertically to close the work

 ISBN: 978-1-61208-575-3

space in which the designers act. The same image that is pre-treated to provide users with a 360 ° view of the inside the project can be projected on its surface. This projection helps designers immerse themselves in real time in their sketches while drawings appear on the tablet in front of them.

An experiment involving these two devices to design a project was set up. Two groups of designer (students of University of Liege and the School of Architecture of Nancy), who were geographically distant, worked for about 3 hours. The synchronous use of HIS and SketSha at this collaborative meeting involved two virtual work spaces that share a resembling feature, namely the sharing of graphic documents in real time on the digital table between the users taking part in the meeting from two geographically distant offices. However, these two devices are distinguished by the HIS-device's immersive dimension. Therefore, our first research question relates to the activity of actors in each work space called (Work HIS and Work SketSha).

Thus, we will study the "duration" and "occurrence" of the two main activities of actors were studied, namely designing and being able to look in both work spaces. Our second research question concerns the modes of switching from one work space to another. Our hypothesis is based on the existence of two types of switching used by the actors: (1) switching between Work HIS and Work SketSha, (2) switching between 2D and 3D.

It should be noted that although the HIS requires physical precedence of some immersive space throughout the meeting, the mode of the presence of the immersive space for the meeting depended primarily on the activities of users and how they made this immersive space (from 2D to 3D) real. On the other hand, it was necessary to compare these remarks with collective operations involved in this collaborative architectural design. This parallelism enabled us to notice the specific particularity of time used for each tool during a collaborative session. Once we determined the decisive moments of the two types of switching, we noticed the specificity of these changeovers and then analyzed them from the point of view of the aspectualization defined in the field of linguistics and semiotics.

III. METHODOLOGICAL POSITION

The question that we pose is: how can the ideas related to the notion of aspectuality help us describe the complex collective activities and enable us to specify the methods of changing from one immersive work space to another work space? In fact, other scientific fields have taken an interest in the analysis of collective activities. For example, in sociology, the question has been asked in terms of the organization of actors' roles in a team [5], or in terms of recognition, personal satisfaction and confidence among the different members of a team [6]. In cognitive ergonomics, the questions are centered on the interactions between partners, on the synchronization of the collective activity of design and on the cognitive aspects [7]. When the activities involve new technologies, one finds oneself in the scientific fields of CSCW (computer supported cooperative work). Moreover there are different points of view to analyze this kind of complex activity [8][9][10] :

1) The point of view of the physical aspects of the work: this point of view is only interested in the ergonomic and physical aspect of the space in which the designer works. We speak of the physical space with its acoustic and thermal properties, gestuality, movements, postures, etc.

2) The point of view of the affect is concerned with the psychological or emotional aspects of the designers. This aspect measures the subjective feelings of the designers in relation to their surroundings and their collaborator. Thus, it deals with hierarchical relations and feelings of confidence that unite the different members of a team ;

3) The cognitive point of view looks at the cognitive aspects of the design process that are linked to the situation, the actors and the subject in question. In this case, the conscience of the group, the intermediary objects and the shared reference are parameters to be considered to study these situations ;

4) The organizational point of view's objective is to define the modalities of assistance to the situations of group work or to help inmanaging group-design documents.

Our paper proposes another point of view which tackles the collaborative design activity involving new technologies: semiotics. The reference to the notion of aspectuality in linguistics and in Greimasian semiotics [11][12] helps us to address the question of the appropriation of the two tools SketSha and HIS, considering time, occurrence and switching. The definition of Holt 13], p. 6, is one of the first attempts to define aspect. According to Holt, aspect concerns "different ways of conceiving the flow of process". The nucleus of this definition remains unchanged. The notion of aspect is currently used in linguistics as a grammatical category that expresses the subject representation of a process denoted by a verb [14] p. 53. Thus, a verb, an adjective or a noun can be analyzed in terms of aspectualization. For example negotiation or decision-making are aspectualized substantives, insofar as the first is considered as an unfinished act and the second as an act already completed. For Bertrand [15], "aspect modulates the semantic content of the predicate, whether it is in past, present or future". Via this notion of aspectuality it is possible, for example, to address the issue of the progress of a process otherwise than by time. For example, if the aspect is taken in terms of time, it is called "punctual" or "durative". The aspect can be described as "terminative" when it is approached from the point of view of its completion and "inchoate" when it is intended to be the beginning. Here, the process is not only related to time but also concerning the state of its switching (see Section V Results).

This specification in the synchronous use of two tools, supporting collaborative design in an architectural design project, led to the issue of proportion via the aspectuality relative to time, occurrence and switching.

Our methodology is therefore based on this concept of aspectuality with the aim of analyzing quantitatively and qualitatively complementary data from this experiment. A coding scheme was defined for the transcription of a user's activities before the semiotic analysis of the processed data.

In concrete terms, it is a matter of leaning of the three fundamental to elements of aspectuality (time, occurrence,

and switching) to analyze the method of appropriation of the system and to evaluate more precisely the stakes, the limits and the perspectives of each single modality ("drawing" and "looking") and complex ("collective operations of design) during the use of these two tools. Thus an adjustment practice was put forward including speech, drawings and looks. The manners in which the two tools were specified have been appropriated by the different participants / designers.

Before going directly to the presentation of the results, we propose to clarify the context and the protocol of this experiment. Protocol description: the technical device and information processing of experiment. Our protocol is part of a framework defined by different factors: diversity of participants in the experiment, problematic addressed during the design exercise and graphical elements, which were available and shared between the actors.

IV. PROTOCOL DESCRIPTION: THE TECHNICAL DEVICE AND INFORMATION PROCESSING OF EXPERIMENT

Our protocol was part of a framework defined by different factors: the diversity of the participants in the experiment, the problematic addressed during the design exercise and graphical elements, which were available to and shared between the actors.

A. User List (A1, A2, A3, B1, B2, B3, B4, C) and problematic addressed

Three user groups participated in the collaborative session that was analyzed. In Liege, an architecture teacher and two students enrolled in Master Engineer Architecture took part in the project (A1, A2, and A3). In Metz, an architecture teacher, a Psycho-Ergo teacher and two Master students of Architecture from Nancy were connected (B1, B2, B3, B4). The third group, namely the observer team and moderator of the session, communicated from Montreal and represented the client for the project (C). The presence of this group was reassuring from the perspective between the organization of the experiment. An incident caused by a problem of incompatibility between two versions of Skype delayed the launch of the session because of the lack of sound. The fast and effective intervention of the third group succeeded in solving the problem (SketSha was able to communicate by graphic tracks to explain the dysfunction of the sound). All groups shared real-time graphical annotations and exchanged information orally via videoconference.

The problem set for the two teams consisted of reorganizing an existing library. The participants were invited to think about possible and future uses of the existing spaces of the library in order to suggest a reorganization better adapted to contemporary uses and new TIC technologies. They spontaneously focused on a windowed space at the back of the library that offers a view of the surrounding wooded landscape.

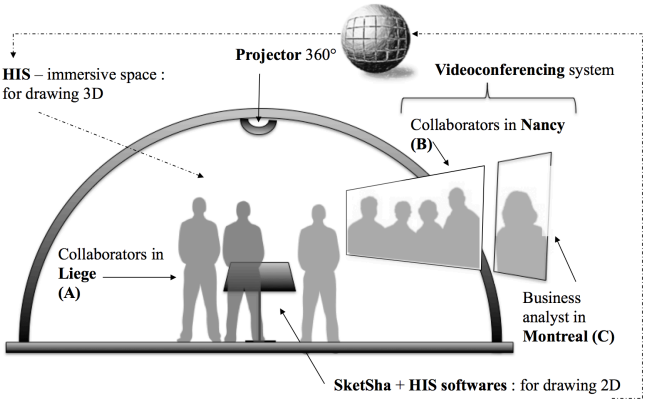


Figure 1. Context of experiment

B. Graphical elements shared on the HIS and SketSha

Students' work focuses on graphical documents existing on SketSha and pictures taken inside the library and prepared to be displayed on the HIS. On SketSha, 3 documents were shared: (1) a floor plan of the existing building with furniture; (2) a floor plan of the existing building without furniture; (3) a view of the property and the insertion of building onto the site. On HIS, different views in human scale were projected in the immersive, manipulated, and annotated space (see Figure 1).

C. Data processing and coding scheme

- SketSha Replay, software designed and developed by LUCID to code a recorded video from a collaborative session according to exclusive criteria. In our case, these criteria were defined according to the three activities (draw, watch, and work together") with the aim of identifying the actions of users in both immersive and non-immersive workspaces.
- List of criteria for coding, criteria that were selected emerged from two types of categories: simple and complex. The first took into account the individual intervention of users in the shared graphic space; the second was derived from the collective activity of each of these two groups.

D. Sequencing coding

Two types of sequencing coding were used that correspond to 1) sequencing at different times that made up the design process (Sequences 1-5); 2) sequencing according to the used tool (Work HIS, SketSha Work, Logistics or Bug).

E. Sequencing of process

- Seq. 1 – the request: the business analyst (c) exposed here his (her) request and all the other actors attempted to understand the objective aimed at by this new project;
- Seq.2 – the state of affairs: different teams exchanged several images of the existing library to understand how the current spaces were experienced and perceived;

 ISBN: 978-1-61208-575-3

- Seq.3 – the challenge of the existing library: after several discussions, two teams of designers decided to increase the space dedicated to reading, considering that this was the first priority for the development of the future library;
- Seq.4 – ICT adapted to the library: designers tried to incorporate new technologies that would be more appropriate for the future library;
- Seq.5 – challenging: the designers brought all current library programs into question and tried to answer this question: "What function to give to future library "?

F. Sequencing according to the used tool

This coding was done according to the work spaces used by actors during the process. We followed verbalization and the intention expressed by actors as they were asked explicitly to change the work space to validate a point of view. (Ex. "Can we switch to the HIS"). We proposed this coding for the entire duration of the collaborative meeting with the aim of realizing all switching from one tool to another during the experiment, and this was perfectly consistent with the initial objectives.

- "HIS" work space: Here, actors used the HIS device (by drawing in 2D on the digital tablet placed in front of them and by looking at their interventions projected on the canvas with 3D printing) for the synchronous sharing of documents, discussion and evaluation of their proposals.
- "SkeSha" work space: Here, the actors used SketSha software (by drawing in 2D on the digital tablet placed in front of them) during the meeting.
- "Logistics": All the moments when the actors communicated to adjust logistic problems were coded as moments that belong to the logistics.
- "Bug": It is about technical and computing problems, which caused the interruption of the exchanges in communication between the actors.

G. Selecting a sequence (Targeted Coding)

To collect our quantitative data, we opted at first for coding that targeted a particular segment: that of the third sequence of collaborative activity between users. This segment, which lasted approximately 10 minutes had the characteristics to mark several switches between the two devices. To ensure the accuracy of the coding of this sequence and thereby reduce the errors of interpretation, we included in this segment the end of the sequence, which preceded it and the end of the one which followed it. Thus, on the temporal axis of the observed meeting, the segment handled according to our coding scheme starts at 0:52:10 and ends at 01:12 00. Nevertheless, in this paper only the data relating to the sequence 3 (from 0:52:10 to 1:12:00) were quantitatively analyzed to prevent interruption of the special results of switching made during this sequence.

H. Simple Category: drawing and watching

Drawing. This category involves three criteria:

- Drawing SketSha: actors draw on SketSha.
- Drawing HIS: either actors draw on the tablet (2D) or they draw on the immersive space (canvas gives a 3D effect).
- Not drawing: the players do not draw.

Looking. This category involves six criteria:

- Looking SketSha: actors look at and follow the documents on SketSha.
- Looking HIS 2D: actors look at documents on HIS 2D.
- Looking HIS 3D: actors look at the documents on the HIS in the immersive space.
- Looking Visio: the actors make contact with their partners in inter-teams by looking at the videoconference.
- Looking at the other in situ: actors see their partners in the same team.
- Unidentified looking: looks are not identified (e.g., out of sight for observer).

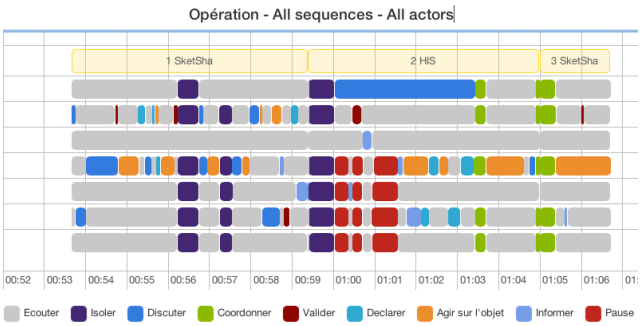


Figure 2. Timeline of Operation – All sequences – All actors

I. Category complex: collective operations of design

Processing of this category is to detect the different operations carried out by each of the actors working together. To do this, the analyses were based on the plots and words exchanged between the designers (see Figure 2). We have identified nine types of action [16]:

- Listening: this operation involves taking information from a program or other participants.
- Informing / sharing: This operation enables the designer to inform others and / or share their references, details of program or context.
- Declaring intentions or choices / raising a question: for this, the designer suggests and / or declares a new intention or question without trying to represent or to formalize it.
- Taking action on a subject: by this action, the designer formalizes his/her intention or ideas by graphic representation.
- Discussing / evaluating / questioning: this operation is reflected in the fact that an actor checks and/or discusses the proposals of another.

- Validating/ collective decision-making: it is to confirm or exclude an entire proposal related to the designed object.
- Isolating: This process occurs when a group is isolated from the other group, either by choice or by the bugs, and cuts the Internet.
- Coordinating / constructing the strategies of group: for this operation, the group is organized and / or sets up the meeting and / or tasks in order to work together, to validate group work strategies and / or to resolve disagreements between designers.
- Intent break: this operation is involved when one actor interrupts the discussion to say something, for example, to tell a joke.

V. RESULTS

The results presented in this paper only relate to the sequence 3 (increasing the space dedicated to reading), which was divided into sub-sequences considering the work space used, with the aim to observe more precisely and separately the appropriation of each tool (SketSha / HIS), and also to observe the changeover from one to another (1 SketSha / 2 HIS / SketSha 3). We relied on an index according to the verbalization in order to divide this sub-division into two moments of switching; A2: "could we switch to HIS?" B1: "Could we shift to SketSha?" (see Figure 3).

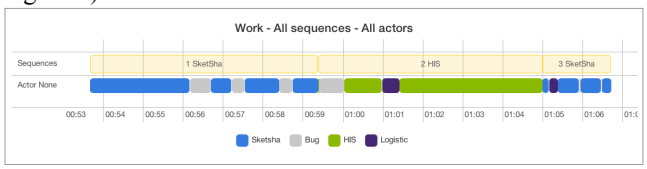


Figure 3. Progress of design according sequencing

Each Each of these sub-sequences was analyzed by using the proposed categories ("looking", "drawing" and "working together") with respect to the concept of "aspectuality." This concept allows a more accurate assessment of the issues, limitations and perspectives of each mode during the use of these two tools.

The time enables the measurement of duration of the act of looking, drawing and working together for each actor in his/her workspace. For example, depending on the relative length of the action, we distinguish two categories. The first is called “Punctual” when the designers decide to go from one tool to another. The second is related to actions that last such as when the designers discuss a problem related to the project being designed. This action is thus called “Durative”.

The occurrence allows us to measure how often an action took place during the design process. In reference to semiotics, if an action is repeated (in relation to another) in a rhythmic manner and more or less orderly in a specific workspace (Sketsha or HIS), the aspectuality of this action is qualified as “Repetitive”. For example, if each time an actor draws on the Sketsha tablet, the other actors look at the HIS canvas, there is repetition. If this repetition does not seem to correspond to a rule or logic, it will be qualified as being “iterative”. For example, it is not systematic if an actor picks up his pen and draws to discuss an idea or to suggest a solution.

There were also cases in which the action happens only once in a specific workspace. This occurrence that denotes "single" seems significant because it can highlight the manner that a user, with regard to the tools, can appropriate his/ her work environment.

Finally, switching enabled the analysis of the data qualitatively according to the time of passage from one workspace to another (SketSha > HIS / HIS > SketSha). With reference to semiotics, aspectuality of the action is described as "Inchoate" if the action is at the beginning of a workspace. But, the action is called "Terminative" if it takes place around the end of the workspace.

So, we rely on the three elements (time, occurrence and switching) to analyze the mode of appropriation of these tools.

A. *Appropriation of "duplicate" and "distinctive" practices according to the time and occurrence*

In this part, we distinguish duplicate practices from distinctive practices in the concept of appropriation. According to a common functionality permitted by SketSha as well as by HIS (synchronous sharing and remote graphical annotations via a tablet), actors can work together by passing from a 2D representation to an immersive representation in order to collectively design the architectural project.

The duplicate practice corresponds to the use of this common functionality between two tools. But, the distinctive practice is the use of an additional functionality. For example, the HIS also allows the use of immersive space via the 360° projector on the canvas surrounding the actors. But this immersion function is not permitted via Sketsha.

The appropriation of the use of a device combining these two systems presupposes an adjustive practice, which is halfway between duplicate practice and distinctive practice. To better understand the implications of this adjustive practice, our concern extends to the drawings, looks and words, as well as to collective operations involved in the context of architectural design activity. It must be remembered that in this experiment the actors are all invited to design a futuristic library where the need of improvement and increase of space is raised.

B. *Word exchanging, drawing and looking*

Since there is only one pen for each team, actors in the same team cannot draw at the same time on the same workspace. However, the partner who does not have a pen can "show" items on the shared tablet, he/she can "look" and comment on the projected images on immersive space and can "discuss" with all the others. As the action of "drawing" can be combined with other actions such as "looking", "showing" and "discussing", it cannot be involved except (1) in the HIS work space, (2) in the Sketsha work space. The actors can never draw simultaneously in both HIS and Sketsha workspaces. From the perspective of occurrence, the act of drawing is considered single in a workspace. But it is important to note that throughout the process, the act of drawing in Sketsha (about 10 %) is double compared to that

 ISBN: 978-1-61208-575-3

performed on the HIS (about 5 %). The rest (85%) of the actions, which are considered as "not drawing", 1/6 of the design process in this sequence is dedicated to words and discussions between participants that are not represented graphically. Nevertheless, it becomes iterative at the end of process because when more designers advance in their choices, the percentage that is dedicated to drawing increases too.

From the point of view of time, drawing in a punctual manner corresponds to the plans' zoning. This enables actors to show zones that relate to the discussion about the project. By this action, they focus their discussions on shared graphics and make sure that all participants share the same "common ground" [17]. The act of drawing is durational when it comes to act on the subject or to discuss and evaluate potential opportunities and eventual choices for the project. By sharing this chart, they shape their discussions and synchronize cognitively the proposals of each other [18]. Therefore, drawing is done by punctual actions as well as by durative actions in both HIS and Sketsha workspaces. The punctual drawings play a demonstrative role while durative designs play an explanatory and / or argumentative role.

On the other hand, in the sequence studied, an adjustive practice specific to words, drawing and looking drew our attention. Certainly, realization of ideas happens mainly through statement and discussion between the actors because the words are meaningful, insofar as they provide elements to specify how actors contribute to the progress of the collective design. However, by comparing the action of "speaking" with "drawing", considering the time, "drawing" becomes a punctual adjustive practice during the conversations in order to clarify and explain an idea. Furthermore, aspectuality of action (durative for speaking and punctual for drawing) could be significant when combined with the activity and the space in which it operates. Indeed, it is necessary to understand how the use of a functionality of a specific tool seems relevant or not at a specific time of collective design. The proof is the example of a designer who asked first to switch from SketSha to HIS (immersive space) because of a disagreement about the quality of light on shelves. This was then followed by a new switching when another designer requested to switch back to SketSha in order to graphically show a point that needed to be developed.

"Looking" is considered as punctual action in some cases and durative in other ones. In both work spaces, watching videoconference and looking the other participants in situ are relatively punctual actions (considering the time) but also repetitive (considering the occurrence). In HIS, we found fewer effects of going back and forth between videoconferencing and the image projected on the canvas (3D) or the one that is produced on HIS 2D tablet.

It seems that actors focus more on their annotations and graphical elements shared and produced on tablet rather than expressions of their remote partners in video conferencing or in immersive space. In occurrence, more than 3/4 of looks are directed to the workspace for the annotation in 2D. For example, "watching a videoconference" only makes participants sure about the presence of the other or about the interest of the others in conversation or the reactions of others to what has been proposed. In this case "looking at the other one who is in situ" is significant. The actors look at the others in a punctual manner (in time) but repetitive (in occurrence). " When I look at the other one, it puts my mind at rest and then I go back to my job," said one participant.

Furthermore, the action of "looking" becomes durative when one of the designers acts on the subject by using the system of SketSha for annotation. In this case, all participants look continually in the direction of the tablet. Some also look at the picture projected on the canvas. However, when actors use only the HIS system, the one who is drawing looks rarely at the canvas (HIS 3D). He/she focuses mostly on the tablet (HIS 2D). At the same time, other users look only at the canvas on which the produced sketch is projected in 360 degrees.

"Looking at the immersive space" is involved in a punctual manner (when it comes to check punctually the validity of a choice of 2D in 3D space) and in a durative manner (when it comes to test a choice in 3D space). In terms of occurrence, this involvement is nevertheless iterative and non-repetitive as designers look at the immersive space according to their needs and the project's progress without any apparent or pre-decided logic.

C. Specificity of *collective* design

"Evaluating", "validating", "informing" and "declaring" appear to be punctually involved in the process, while other operations (such as "listening", "discussing" and "acting on the subject") are rather durative. Furthermore, it is important to note that the actors never tried to isolate themselves deliberately. Sometimes punctual and sometimes durative, this operation is more related to bugs caused by a network outage or disconnection of videoconferencing. However, almost all of these bugs were consistently tracked by re-questioning (via the "discussing" operation). Sometimes, they caused conflict, which, according to the users, would not have existed if the communication had been continued. Indeed, the actor interrupted by a bug is obliged to re-state what has been said before, and this sometimes causes tensions between groups.

"Isolating", "pausing" and "coordinating" operations are durative (considering the time) and iterative (considering the occurrence). They are involved here as part of the group's organization and work on several subjects for designing.

"Informing" is a punctual action whose occurrence is single in the third division in workspace (3. SketSha) while it operates iteratively in the first two divisions (1. SketSha and 2.HIS). This may be related to the project development and the mastery of problem by designers when the need for information sharing becomes less and less necessary but the action on the subject gains more importance at the end of process.

"Acting on the subject" is not only a durative operation, but also iterative because it does not follow any rule and can occur several times during the discussion.

"Validating" is punctual and repetitive because it is preceded every time by a discussion.

 ISBN: 978-1-61208-575-3

"Discussing" is a durative operation (by time) and iterative (by occurrence). If the operation involves a disagreement, it usually induces the request for switching from a workspace to another.

D. *Appropriation relative to the time and the occurrence of the process*

Based on quantitative data from codings, we correlated, in entire process, the specificity of time and occurrence of three categories: "looking" (in Figure 4), "drawing" (in Figure 5) and "working together" (in Figure 6). These three schemes summarize the correlations for the whole process. This correlation can chart the actions and operations using both types of aspectuality; one relating to the time and the other to the occurrence.

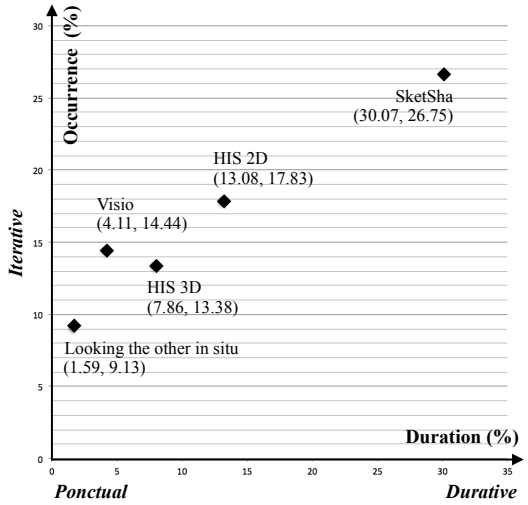


Figure 4. Correlation time/occurrence for " looking " (%).

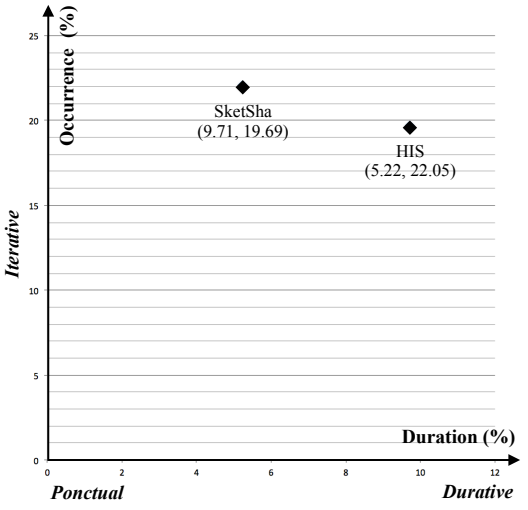
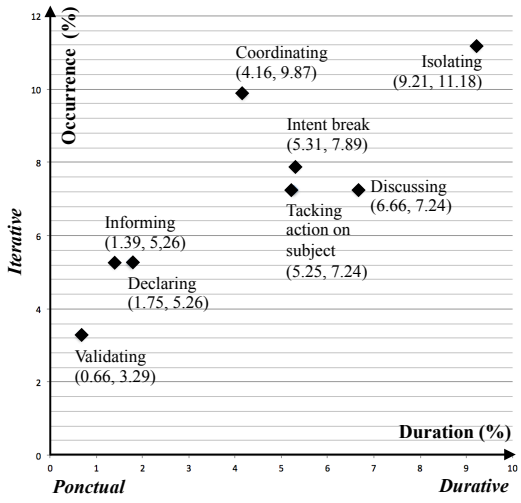


Figure 5. Correlation time/occurrence for " drawing " (%).

Returning to the aspectuality of actions of each of the three sub- sequences in each workspace (see Appropriation of a "duplicate" and "distinctive" practice according to the time and occurrence) we deduced identical results.



	Validating	Informing	Declaring	Coordi-nating	Taking action	Intent break	Discussing	Isolating	Listening
% Duration	0,66	1,39	1,75	4,16	5,25	5,3	6,66	9,21	65,61
% Occurence	3,29	5,26	5,26	9,87	7,24	7,89	7,24	11,18	42,76

Figure 6. Correlation time/occurrence for " Collective operation for design " (%).

The parallelism between these results and those put forward by charts shows that the actors appropriately duplicate practice in the same way in HIS and SketSha.

However, this parallelism is not easy concerning the distinctive practice. Indeed, we note that aspectuality is not the same from one workspace to another. If the actors refer in a punctual manner to the immersive space when they act in SketSha, they look for a long time at immersive space when switching their work to HIS.

This contrast can be explained by the degree of conformity between the functions basically provided by each tool (during their development) and uses that designers make (after combination of two tools in this experiment). The actors seem to adopt an adjustive practice (a practice between duplicate and distinctive) that seems to be in accordance with the potential of the tool and the manner it is set up by the user.

E. *Appropriation of a collective practice of switching from one tool to another*

To better understand the modes of switching from one workspace to another, we refer to the aspectuality called inchoate or terminative in this context (see Figure 3).

Qualitative analysis shows that the terminative aspect is related here to the discussion. In fact whenever there is: (1) Either a disagreement between actors about a proposal by one of them (2) Or uncertain understanding of participants about a new choice announced, designers suggest switching to another work space (from SketSha to HIS and HIS to SketSha). In this experimental context, the terminative element is imprecision and disagreement. As long as switching from HIS to SketSha is a way to check what was decided in the immersive space, actors have the opportunity to look at the same time at the canvas where annotations previously made in 3D by HIS are projected and at the tablet exposing documents and new annotations made on SketSha.

 ISBN: 978-1-61208-575-3

So, actors can easily compare their choices for workspace. In this case, the designers are in a distinctive practice. The converse is not correct because during the switching from SketSha to HIS, the workspace for the first one disappears from the display on the tablet, and leaves the interface to the HIS workspace. The designer draws on the tablet (HIS 2D) while the other participants look at the annotation performed in the immersive space of the canvas (HIS 3D). In this second switching, designers are in a duplicate practice.

Considering therefore the operations of "challenging" the actions performed on the object and "statement" of new proposals as terminative elements in the process of switching from one work space to another, the validation becomes an inchoate element in the process. This element marks the beginning of each switching in the use of a tool. This operation is then followed by several operations that enable the users to act on the object to be designed.

An iterative process between questioning, validation and acting on the object continues throughout the work of designers while the use of a particular tool plays a predominant role in making decisions. Indeed, even if two systems originally offer the same function for real-time and remote sharing of graphical annotations, their specificity (immersive space / non-immersive space) suggest another perspective on the object to be designed. This specificity provides a new workspace, negotiation and consensus-building between participants and allows them to test and validate their choices.

VI. CONCLUSION

Contribution. Our research concerned the modes of appropriation of an innovative collaborative platform, to instrument distant and synchronic design by associating two tools, which support artifact annotation in real time.

This work allowed us to develop an analytical method that uses concepts related to semiotics in order to observe systemically the collective activity of design using various tools at the same time. In fact, through our data analysis and by using this method at the border of the fields of cognitive ergonomics and semiotics, we could clearly identify the use of 2D, the use of 3D and switching from one to another. In other words, what makes an actor switch from one to another? The observation of this practice that is at once "duplicate" and "distinctive" showed that look, drawing, and word (representing "working together") play an important role.

It is obviously possible to draw in a tool and look simultaneously at another workspace, and this was observed during the use of SketSha (2D plans on tablet produced parallel to the interior image of library, which was projected in the immersive space. In this case, it was not a switching from one tool to the other but an oversizing of the workspace. The activity was not just in 2D or 3D, but it was oversized to offer two different perspectives simultaneously for a single area of the designed object. Even when actors worked in space dedicated to SketSha, they occasionally referred to the immersive space. However, in the context of use of the HIS device, the interface of HIS 2D appearing on the tablet involves systematically the disappearance of the SketSha workspace. A definite switching from one activity on a tool to a new activity on another tool is marked.

Moreover, aspectuality related to switching of certain collective operations shows the effectiveness of the combination of two tools in order to validate the collective choice in the collective and remote design of a project. In both cases of switching (1) from SketSha to the HIS and (2) from HIS to SketSha, appropriation of a tool's specific functionality allows designers to better understand the ideas expressed, to build a common ground and to move forward together in a preliminary design phase. Nevertheless, the recurrent problem of bugs and sound dropping during the videoconferencing due to network disconnection did not help to build awareness among participants. This even caused some conflict between them. Both findings highlight the notions of completion and accomplishment throughout a permanent evaluation of ideas in the process. If all the operations that we have emphasized are essential in these early stages, it would still be considered a privileged place for punctual operations such as "informing", "declaring" or "validating together" which require good functionality of the tool.

Limitations. Focusing on the modes of simultaneous appropriation of these two tools for collaborative design, this research is certainly not intended to be generalizable to other cases of tool and device combination. Nevertheless, the method implemented for processing and analysis of this type of combination is still interesting because it combines quantitative and qualitative data in a systematic, repeatable and disciplined approach. To further this approach and prove its validity, it is necessary to confront other contexts of using combined tools by exploiting the concepts from the field of semiotics.

In addition, semi-structured interviews were conducted as part of this experiment, but these data were only used partially in our analysis.

The in-depth processing of designers' feedback will enable the issue of aspectuality to be addressed in greater detail from the users' perspective by reference to how they describe their experiences of appropriation of combined tools.

Prospects. We plan to apply our approach (1) on one hand in longitudinal observations to analyze the evolution of this appropriation process in time and (2) on the other hand, to observe new collective activities such as participative production of a same artwork from distance.

REFERENCES

[1] T. Dorta, Y. Kalay, A. Lesage, and P. Pérez, "Design conversations in the interconnected HIS", in Carrara G., Fioravanti A., Trento A. (eds.), Connecting Brains Shaping the World : Collaborative Design Spaces, EuropIA 13, Rome, pp. 83-94, 2011.

[2] http://www.hybridlab.umontreal.ca/his.php?l=fr, last access in April 2017.

[3] S. Ben Rajeb and P. Leclercq, "Using Spatial Augmented Reality in Synchronous Collaborative Design", Yuhua Luo éd., In Lecture Notes in Computer Sciences, Springer, vol 8091, pp. 1-10, 2013.

 ISBN: 978-1-61208-575-3

[4] http://www.sketsha.be/F11_Innovation.html, last access in May 2017.

[5] J. G. Breslin, "Social Semantic Information Spaces", in Semantic Digital Libraries, pp. 55-70, 2008.

[6] M. Lourel, S. Abdellaoui, S. Chevaleyre, M. Paltrier, and K. Gana. "Relationships between psychological job demands, job control and burnout among Firefighters", in North American Journal of Psychology, 10(3), 489-496, 2008.

[7] F. Darses, M. Wolff. "How do designers represent to themselves the users' needs?", in Applied Ergonomics, 37 (6), pp. 757-764, 2006.

[8] J. F. Boujut, P. Laureillard, "A co-operation framework for product process integration in engineering design", in Design Studies, 23 (5), pp. 497-513, 2002.

[9] P. Carlile, "Transferring, translating and transforming: an integrative framework for managing knowledge across boundaries", in Organization Science, 15, pp. 555-568, 2004.

[10] J. M. Carroll, D. C. Neale, P. L. Isenhour, M. B. Rosson, and D. S. McCrickard, "Notification and awareness: synchronizing task-oriented collaborative activity", in International Journal Of Human-Computer Studies, 58, pp. 605-632, 2003.

[11] A. J. Greimas and J. Courtés, Sémiotique. Dictionnaire raisonné de la théorie du langage, (translated by "Semiotic. Dictionary of the Language Theory"), Paris, Hachette, 1993.

[12] J. Fontanille, Le discours aspectualisé, PULIM, Limoges, 1991.

[13] J. Holt, Etude d'aspect. (translated by "Aspect studies"), Acte Julandicia. 15 : 2 Copenhague, 1942.

[14] J. Dubois and al., Grand Dictionnaire de linguistique et des sciences du langage, (translated by "Dictionary of Linguistics and Language Science"), Paris, Larousse, 2007.

[15] D. Bertrand, Précis de sémiotique littéraire (translated by "Literary semiotics"), Paris, HER, 2000.

[16] S. Ben Rajeb S., "Conception collaborative distante : étude architecturologique pour la caractérisation des opérations cognitives" (translated by "Remote collaborative design : architecturology analysis to specify cognitives design operations"), V. Angenot, S. Safin, M.G. Dondero & P. Leclercq éd., In Interfaces numériques : Collaborer à distance, enjeux et impacts des interfaces numériques dans les pratiques collaboratives synchrone, Lavoisier, 2 – n°3, pp. 509-530, 2013.

[17] J. Beers Pieter, H. P. Boshuizen, P. A. Kirschner, and W. H. Gijselaers, "The analysis of negotiation of common ground in CSCL ". Learning and instruction , vol. 17, n°4, p. 427-435, 2007.

[18] F. Darses, A. Mayeur, C. Elsen, C., and P. Leclercq, "Is there anything to expect from 3D views in sketching support tools?". Gero, J., Goel, A. (eds.) Design Computing and Cognition 2008: Proceedings of the Third International Conference on Design Computing and Cognition , Atlanta, USA, pp. 283–302. Springer, 2008.

 ISBN: 978-1-61208-575-3