

Study of the Appropriation of Groupware in the Context of Remote Collaborative Design

Aspectuality via time, occurrence and changes

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Abstract— This article presents a methodology of analyzing the appropriation of groupware in the context of collaborative design via the idea of aspectuality (punctual, iterative, durable, inchoative, and terminative), well known in the field of Greimasian semiotics. This idea guides us in the definition and the categorization of the modes of appropriation of tools, as well as the passage from one tool to another during a collaborative activity. To do this, our research focuses on the study of an innovative device, associating two tools for remote synchronous collaborative design: HIS (Space Hybrid Ideation of Hybridlab), and SketSha (Sketch system of sharing from LUCID-ULg). These two tools enable the annotation of graphical objects in real time. HIS enables immersion into the interior of a virtual representation of a designed space, the other (SketSha) enables the possibility to share and to act on the 2D documents. In our experiments, these two tools were associated to form a system enabling two groups of student designers to work together remotely and in real time. Two questions came up in this original experimental situation: the first concerns the singularity of each tool and the second touches on the degree of compatibility of the two devices making up a system for synchronous exchange and collaboration. To answer these questions, we will describe the experimental protocol put in place in the simultaneous use of these two tools. Then, we will present our methodology of analyzing the data based on self-analysis as well as the qualitative and quantitative treatment of the data put to work in the experiments. Finally, we explain in detail in which manner the two devices are complementary and can be articulated in the preliminary phases of architectural design.

Keywords— component; groupware; appropriation and tools uses; semiotics; aspectuality; computer human interaction.

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. In this paper, we explore a previous study, presented in [1]. The two tools are the Hybrid Ideation Space (HIS), developed at the Hybridlab, a laboratory of University of Montreal [2, 3], and the Sketch Sharing system (SketSha), developed at

LUCID, a laboratory of University of Liege [4, 5]. 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 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 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 (Figure 1). 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.

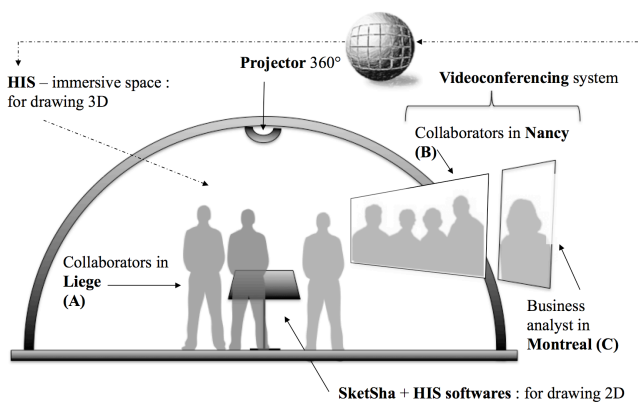


Figure 1. Context of experiment.

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 [6]; or in terms of recognition, personal satisfaction and confidence among the different members of a team [7]. 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 [8]. 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 [9, 10, 11]:

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 in managing 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 [12, 13] helps us to address the question of the appropriation of these two tools considering time, occurrence and switching. The definition

of Holt [14], 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 [15] 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 [16], "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). 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 were specified in the two tools have been appropriated by the different participants / designers. But before going directly to the presentation of the results, we propose to clarify the context and the protocol of this experiment.

IV. EXPERIMENTAL PROTOCOL

A. Experimentation

Our protocol is part of a defined framework, which involves the following parameters.

- Role of the actors participating in the experiment: the participants are formed with a sponsor (Actor C is in Montreal and is also the moderator of the session) and 7 designers divided into 2 groups (group A is in Liège and group B is in Metz);
- Hierarchical relations between the designers and their expertise related to the use of the tool: these designers are trained by experts (represented by teachers who are used to using the two tools) and novices (represented by students who have already

used Sketsha several times but have worked with HIS only one time);

- Training of the designers: Group A includes 3 actors of whom 2 are students in Master's Engineer-Architect and their teacher at the University of Liège (A1, A2, A3) while Group B includes 4 actors of whom 2 are architecture students, their teacher in architecture and another teacher specialized in ergonomic psychology (B1, B2, B3, B4);
- Problem of design, pointed out by the sponsor, in relation to the rearrangement of a library: to solve this problem graphic elements (images of the interior space treated in 360° able to be projected on the HIS screen and some plans as well as simple pictures taken in the space can be used and annotated directly on SketSha) were made available to the designers and shared.

All the actors were first invited to use the whole system (HIS and Sketsha simultaneously) at least one time. This experience 0 gave them the opportunity to take in hand the tool and to exercise in a completely different context before doing the experiment concerned by this study.

All the geographically remote actors work in the same kind of environment that associate HIS and SketSha. The designers share the graphic annotations and exchange orally via the video conference in real time. The problem the 2 teams must work on consists to more precisely rethink the library of the future starting from an existing site and a real context. The designers formed from groups A and B are led to think about the possible uses of current spaces of the library in order to propose a rearrangement of the space better adapted to contemporary uses and new TIC technologies. Their work is about graphic documents that already exist on SketSha and pictures taken in the library and prepared to be visualized in HIS. On SketSha, 3 documents are shared: (1) a plan of the present floor in consideration with the furniture; (2) a plan of the present floor in consideration without the furniture; (3) a view of the ground and the insertion of the building on the site. On HIS, different views in human scale are projected, annotated and manipulated.

At the end of this experiment, 3 hours and 15 minutes of video recording had been taken by the Montreal team. To make the work of the researchers easier, this recording is made up of a juxtaposition of 4 views showing (Figure 2): a shot of all the traces made by SketSha (upper left), a view of the HIS environment in Montreal, appearing in the same way as on all the other sites (upper right), a view from the webcam in Metz (bottom left) and a view from the webcam in Liège (bottom right).

Only 2 hours were treated in the framework of our study. The first quarter hour of set up was deleted and an hour and the end of the work seance during which the designers could no longer communicate because it was interrupted by recurring moments of bugs caused by the video-conference system.

At the end of the experiment, we had a semi-open interview with the designers in order to get their spontaneous feedback. In the context of our study, only the designers

from group A were questioned because we were geographically in the same place. We did not try to separate the designers during the interview because our research did not focus on the designers' individual use. On the other hand, we were more interested in the appropriation of the system by a group of users participating in a collaborative activity.



Figure 2. Juxtaposition of 4 views: graphic elements produced by the designers and views from Montreal, Metz and Liège sites.

B. Methods of data processing: from self-analysis to video processing

In the logic of complementary data and inspired by the field of cognitive ergonomics, our methodology of data processing was divided into two steps. First, we applied the method of ergonomics with group A with the aim of getting their feelings (tiredness, concentration, stress, annoyance, discouragement, enthusiasm, etc.) and their feedback in relation to their use of the tool, but also in relation to their appropriation of the whole system. To do this, we used the semi-directed interviews made at the end of the experiment to construct our chart of self-analysis. Secondly, we processed the video by making cuts in relation to a coding scheme, which was specified by our state of the art, but also by that which was cleared and highlighted in the framework of the self-analysis with group A.

1) Protocol of the self-analysis

Lasting about 3 hours, several steps made up the self-analysis done with group A in the context of our study:

- we reminded the designers the context of the experiment and the main steps, which made up their design exercise;
- then we explained the modalities of the self-analysis that consists of commenting on 10 short sequences of about 4 minutes from the video recorded during the experiment. These 10 sequences were selected in a way to cover the group of phases, which made up their design exercise;

- in addition to the video placed on the table, we gave them a frame of reference made up based on the interview carried out with them following the experiment. This chart took into consideration the following points:

- relationship between the actors,
- evolution of the project over the time,
- modalities of communication between the actors,
- specific use of each tool,
- appropriation of the system using the two tools when they were used simultaneously.

An example of this frame was placed on a table in front of them, near the video (Figure 3). Opposite them, on the wall, were posted 10 examples of this chart representing each of the 10 sequences selected for this seance of self-analysis;

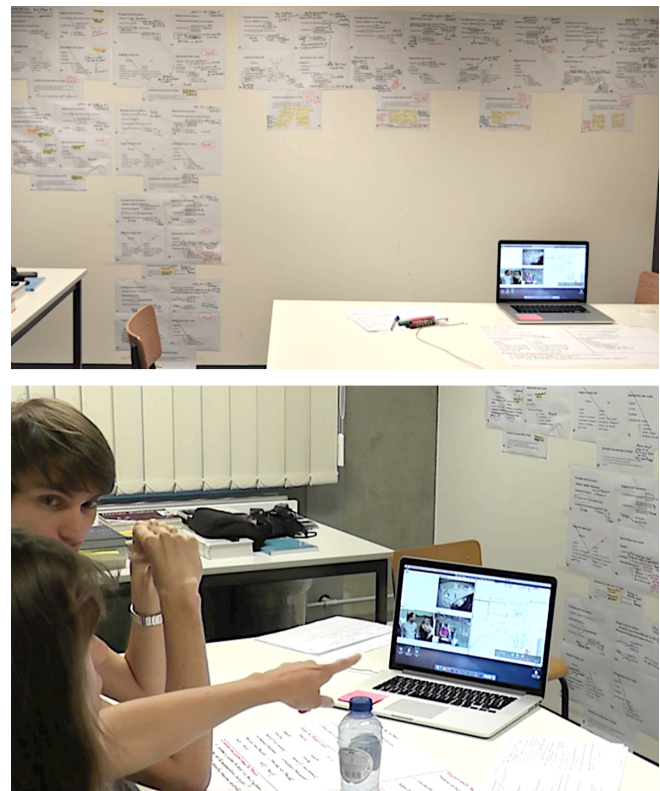


Figure 3. Self analysis set up.

- after looking at each sequence, the chart was collectively filled in with the researcher using pens (with different color codes related to the feelings of each actor) but also post-its so they had the possibility to add something if they think that an example, an explanation or an argument should be added to one or another element than the chart offered. The designers also have the possibility to go back while looking at the video in order to verify something that was said or one of their feelings;
- when all of the charts shown on the wall were filled in, the designers were asked to re-do a synthesis

relative to their individual or collective or collaborative activity on the tool, or their collective activity or interaction with the other group. In other words, it means firstly, to spot their concrete actions on this or that tool and, secondly, the moments where they think they could have collaborated with group B. Then we asked them to also spot moments when each group isolated themselves on the side without the possibility of negotiation or collaboration between the two groups;

- at the end of this exercise, a feedback on the use of HIS/SketSha was requested in relation to their experiment 0 by which they had learned for the first time to use the system.

At the end of this self-analysis, the participants highlighted the contribution of this kind of method which, according to them, enabled them to "show the other aspects of what had happened... it was while watching the video that I realized the impact of the tools on our communication over distance and our group work...".

2) Protocol of data processing via SketSha Replay

The coding done here concerns the video of the experiment. It enabled us afterwards to quantitatively analyze the data in addition to that which had been caught qualitatively during the self-analysis. For this coding, the data were treated via SketSha replay. This software, designed and developed in the LUCID laboratory, enables the coding of a video recorded the coding of a collaborative seance according to exclusive criteria. In our case, these criteria were specified thanks to elements that were highlighted by the designers during the self-analysis. The coding criteria centered most precisely on the three following criteria: "drawing", "looking", and "doing together", the objective being to spot participants' actions in the two work spaces, immersive and non-immersive, in relation to the use of HIS and SketSha. Out of the three main activities two types of categories emerged: simple and complex. The first takes into consideration the individual intervention of the users in the shared graphic space; the second was deduced from the collective activity of each of the two groups of collaborators (A and B). To do this, we first proceeded with a temporal cutting of the sequence (from 1 to 6) in relation to the different steps of the designing process. From this temporal cut, we then selected a sequence, which especially shows the switching from one tool to the other, as well as the use of the two.

3) Division into sequences.

This division remains nevertheless subjective even if it was validated during the self-analysis. It depends mostly on the objectives researched in the framework of this study. A sequence indicates, in our opinion, "a series of sequential choices forming a narrative unit that answers to a general problem by the actors during the designing process". Each sequence involves thus a beginning and an end marking the passage from one subject to another and/or the transformation from one state to another (and/or a proposal) but does not systematically end with a solution (and/or an answer to this proposition) [17], p.185.

In this way the work seance being studied here is cut into six sequences (Figure 4):

- Sequence 1 (45 minutes) – Understanding the request: this sequence is the longest in the design process. Now, the sponsor (C = commanditaire) explains his request and all the other actors try to understand the objectives aimed at by the new project. The actors begin by visualizing on SketSha then on HIS all of the elements that they have been given. Then, they try to construct a common understanding of the plan that has been given to them by SketSha. After this, all of the actors try to clarify the request in order to specify the new elements to be integrated in the project.
- Sequence 2 (6 minutes) – Increasing the space dedicated to reading: after discussion, the 2 groups of designers decide to increase the space dedicated to reading estimating that it is the first priority for the arrangement the future library.
- Sequence 3 (14 minutes) - Integrating the light: in negotiating the arrangement dedicated to reading, the designers decide to create two kinds of space (zones of conviviality and zones for reading) according to their proximity to openings.
- Sequence 4 (18 minutes) – Integrating new technologies: by trying to optimise the space, the designers question certain existing functions and thus decide to integrate more adequate new technologies to the future library.
- Sequence 5 (21 minutes) – Calling into question: the designers call into question the whole current program of the library and try to answer the question "What function to give to the future library"?
- Sequence 6 (12 minutes) – The first attempt to rearrange: after the intervention of the sponsor, the designers decide to work immediately on one of the main spaces of the present library having good light quality and whose facade has an non-standard shape: that of a bite.

In the context of this article, we have chosen a coding aimed at a particular segment in order to gather our quantitative data.

4) Choosing the segment.

To choose this segment, we first proceeded with a cut relating to the work spaces used by the actors during the design process. We based this on the verbalisation and the intention expressed by the actors when they asked to modify, explicitly, the work space to validate a point of view. We proposed this code for the entire length of the work meeting with the objective to take into account all the switches from one tool to another during the experiment, which is perfectly coherent with our objectives from the start. We also stressed the importance of the moments during which the designers did not work together: "Bug" moments caused by problems with the video conference and moments of "Logistic" management. Thus, this first cut was done according to the following criteria:

- "HIS" work space: here, the actors used the HIS device (by drawing in 2D on the digital tablet placed in front of them and looking at their interventions projected on the screen with 3D printing) for synchronous sharing of the documents, the discussions and evaluation of their proposals.
- "SketSha" work space: here, the actors used the SketSha software (by drawing in 2D on the digital tablet put in front of them) during the meeting.
- "Logistics" moment: all the moments when the actors communicate in order to adjust the problems concerning the logistics are coded as belonging to the logistic.
- "Bug" moment: it concerns technical and computing problems that caused the interruption of exchanges in the actors' communications.

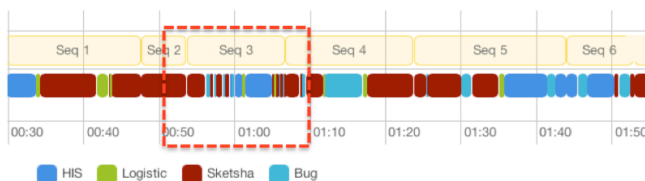


Figure 4. Progress in the design process and selection of the treated segment.

This first cut then enabled us to focus our analysis on the segment centered on sequence 3 that was characteristic of marking several switches between the two tools. In order to assure the coding precision of this sequence and thus decrease errors of interpretation, we included in this segment a bit of the sequence that preceded it and a bit that followed. Thus, on the temporal axis of the observed meeting, the segment we dealt with according to our coding scheme began at 50 minutes and ended at 1h10. Nevertheless, only the data that concerned sequence 3 were analyzed quantitatively, in the context of this article, in order to not alter our specific results to changes made during the sequence.

Thus, we proceeded with a second cut of this selected sequence in sub-sequences relating to the work space used, the objective being to more precisely observe the appropriation of each tool separately (SketSha / HIS), as well as the change from one to another (1 SketSha / 2 HIS / 3 SketSha). Like the first cut, we emphasized the indications relevant to the verbalization marking this change from one work-space to another (Figure 5):

- A2: "Is it important that one can switch on the HIS?"
- B1: "Shall we switch to SketSha?"

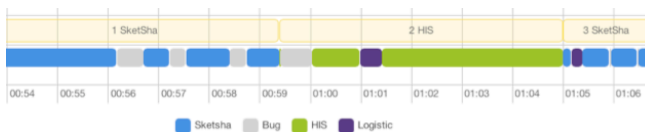


Figure 5. Progress of sequence 3 according to the designers' work spaces.

5) Coding the sequence 3 with SketSha Replay

Two types of codes were done for sequence 3 via SketSha Replay: the first (simple category) takes into account the individual intervention of each user in the shared graphic space ("Drawer" Category and "Watcher" category); the second, "Doing Together" comes from the collective activity of each of the two groups of collaborators (A and B).

a) Simple Category: drawing and watching

Drawing. This category involves three criteria (Figure 6):

- 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.

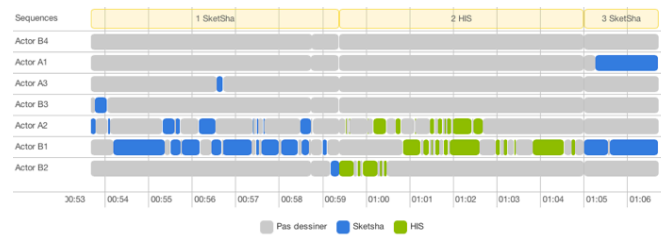


Figure 6. Drawing SketSha, drawing HIS and no drawing actions.



Figure 7. Looking SketSha, Visio, Unidentified looking, looking HIS 2D, HIS 3D and looking at another in situ actions.

Looking. This category involves six criteria (Figure 7):

- 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).

b) 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 (Figure 2). We have identified nine types of action [18]:

- 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: 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: 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.

C. Methods of Data analysis: from a generalized analysis to the specification of sequence 3.

To approach the idea of appropriation of different tools in relation to time, the occurrence and switching, we based our studies on ideas presented above in the state of art (Section III). This is where lies the originality of our method based on complementary data: being the middlemen between two fields, that of cognitive ergonomics and semiotics, between qualitative data on the whole experiment and specific quantitative data about one particular sequence.

We relied on these three elements (time, occurrence and switches) to analyze the mode of appropriation of the system and to evaluate more precisely the stakes, the limits and the perspectives of each modality when the two tools are used.

To do this, we used a visualization tool to process our data. Called COMMON Tools, it is a web platform initiated in the framework of the ARC COMMON project and developed by LUCID of the University of Liège [19]. The tool is made available to researchers enabling them to transform data from the coding frame (in our case SketSha Replay after the coding of the data) into consolidated data then quantified and translated according to different choices of visual formalism (pie, stacked columns, time line, crossing, clouds, etc.). A range of graphics is thus proposed for the analysis of the collective design activity. It enables the formalization of quantitative data, but also to cross them (Figure 8) in relation to time, occurrences, and the specificity of each actor involved in the collective design process, which corresponds totally to what we want to analyze in the context of this article.

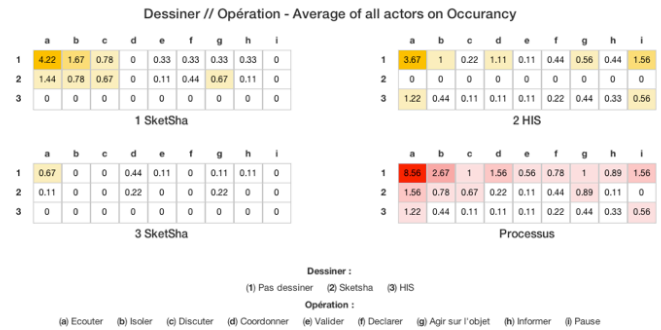


Figure 8. Example of crossing data: "Drawing" x "Operation".

V. INVOLVEMENT OF THE SYSTEM IN THE PROCESS OF NEGOTIATION AND DISCUSSION-MAKING

The results emphasized in this section come from the qualitative analysis of the entire work meeting.

Here, we investigate the involvement of the two tools on the way the actors are brought to work together. It means questioning their collaboration from the point of view of leadership and the transmission of each one's ideas. To what extent can the Groupware encourage or not the collaboration or the idea of leadership? What does the synchronous use of the two tools imply the way the actors will manage a collaborative meeting? What are the risks of instrumentation? Does it mean destabilization or the fixing of ideas?

To answer these questions, we crossed two determining axes in the tooled communication activity: (1) updating through its use and (2) the contextualization. The updating through use corresponds to the way in which the potentials of the association of the two tools have been exploited. The contextualization includes the essential environmental parameters from the user's point of view.

A. The idea of leadership in leading interactions

The interactions between group A (with 2 student participants from Liège A1 and A2) and group B (that was mainly co-directed by the two teachers from Metz: B1 and B2) were not along the same line during all of the work meetings, between the first to the last sequence.

In fact, the hierarchical relation between the designers and their expertise relating to the tool, the training of different actors and the problem of designing experience exposed by the sponsor played an important role in the appearance of the leaders during the designing process.

In the first phase of the process (that lasted 45 minutes), groups A and B focused on understanding the order and the graphic elements at their disposal (phase of pooling of assets). Nevertheless, 2 types of leadership began to appear. The first that could be called "organizational leader", is the teacher specialized in ergonomic psychology (B2) who proposed a team work plan and who took charge of switching from one work space (HIS) to another (SketSha). It was also him who made several jokes to lighten the atmosphere or re-motivate the two groups. He was used to

using these two work environments and had already manipulated them in several experiments being a researcher himself. The second that could be qualified as the 'decision - leader' is the architecture teacher (B1). Being himself in practice and being the one who is the best master in the use of SketSha (tool regularly used in the teaching context) he kept the pen almost all the time in group B. He was the one who drew the most and who made the choices ("in fact, listen... what needs to be done is..."). The actors in group A, with whom we did the self-analysis, claimed that 2 parameters should be taken into account in the B1's stand as the decision leader. The first is linked to the contextualization relating to actor B1, as much as by his knowledge of the tools as by his architectural experience. It means that a hierarchy is created by experience in the use of the device as well as in the actual design experience. When it means proposing an idea that is convergent to that of the experienced user, there should be, according to them, much more certitude and much more energy to transmit the idea. But does the active use of the device decrease the risk of an imbalance caused by the recurrence of interventions of an experienced member instead of users who have less experience?

This is where the second parameter comes into play, linked to the actualization by the use of the video-conference, by its location as well as the tone of the sound that it emits. In fact, the video-conference being completely on the right side of the screen, the actors in group A do not have direct contact with the other collaborators as was the case on SketSha (where the designers were put face to face via the vertical and centered projection of the webcam on the screen). According to them, "we lose a space of eye contact". In addition, the video-conference passes all the sounds with the same tone that makes the idea of proximity or distance lost in relation to the camera: "as if we listen to the radio ... there was no question as to what they proposed... we had the impression that certain choices were imposed or that they did not listen to us...". These two phenomena due to the use of the video-conference privileged, in their opinion, the gap and the hierarchy between the actors.

The first proposal for intervention on the plan (related to the increase of reading space) came up in the 2nd phase, via some annotations on the SketSha work space. Here, also, the relationship between novices and experts was felt very strongly between Liège and Metz as much by the asides that were imposed by group B (group A did not hear anymore what was said between them) as the inter-group B or B1 kept the pen in hand during the whole phase. The actors of group A also insisted on their 'impression of rejection'.

Furthermore, HIS enables one to illustrate a localized and selected point of view that depends on what is chosen and that decides to put it common. The B1 and B2 leaders, being more used to using HIS, chose their opinions, which reinforced their positions as leaders.

In the third phase, group A tried to propose a new method of work centered on the definition of the program of their future library. But this proposal was rejected by B1, followed the entire group B. A bug in the video-conference system created a feeling of being abandoned in group A. The

two groups thus continued to work on the furniture to put in the library. According to them, until that point, there had not been effective collaboration since the lead in decisions had been kept by B1.

But this hierarchy was called into question in phases 4 and 5. Group A tried to show their disagreement as to the method of design that was chosen, which was supported by the organizational leader B2 who intervened in order to build consensus between the two groups: "let's go back to the objectives in the beginning... otherwise everyone will have the idea that we are not making progress". According to group A, his intervention gave back some legitimacy to their proposal, which also helped in re-balancing the statutes between the actors, especially in phase 6.

B. The transmission of ideas and the risk of destabilization

During the self-analysis, the members of group A noticed that in the first phase of the work, they had nearly forgotten the very existence of the two specific interfaces of each of the tools. The information exposed in one helped to better understand what was projected in the other. In fact, HIS enabled a life-size view of the interior spaces of the library giving a feeling of the kind of atmosphere, the quality of the present arrangements, the luminosity, etc. The view of the plan on SketSha enabled, on the other hand, to situate these views and to understand the project as a whole, with practice in interpretation and continual recognition between the view offered by HIS and that of SketSha. This observation highlights (1) the flexibility of changing from one to the other and (2) the complementarity of the views offered by the two tools.

Gradually, as the project continues, the users referred in a casual way to each of the two tools. When an arrangement was drawn on the plan via SketSha, it was redrawn in 3D and simulated in the immersive HIS space ("this enabled us to reinforce the idea not to put little armchairs in this double-high zone... isn't there another way is to consult the book?").

The users then went back to SketSha to increase their knowledge and realize the idea in a more global scale. HIS did not enable them to get a view of the whole, it showed a localized viewpoint selected in the space. Going back to the plan each time thus seemed necessary in this phase of the designing process.

Furthermore, by putting this experiment in parallel with their first experiment 0 using HIS and SketSha, group A explained that the way the program had been first formulated interfered a lot in their way of appropriating the tool. In fact, in the first experiment they referred to the immersive space (HIS) to decide on very precise questions whose answers demanded verification and simulation of the proposals made on the life-size plan with the help of HIS. In this case, the use of HIS was optimal, even if A1 and A2 did not master it very well. It was not the same in this experiment where the problem demanded thinking first about the program and the general objectives of the project before even rearranging the spaces. Through the association of the collaborative tools, going deeper, even if the added value of SketSha remained, the rapid zoning of the spaces and the common understanding of the whole building and organization, the

added value of HIS concerned more the simulation and evaluation of the shared ideas in order to make them evolve. If, with SketSha, they had to try to better define the project and clear up certain ideas, with HIS, they could visualize in a virtual way, their hypothesis on the arrangement of spaces taking into account the scale and the double-height. In other words, they estimated that the targeted use of HIS during the entire collaboration was advantageous in the process of collective design.

Furthermore, another question was about the necessity for short chosen private discussions (and not imposed by a system bug) between the members of a team during a collaborative meeting. Did it seem to be an advantage in the eyes of the group A designers to isolate themselves to discuss together and come to an agreement before communicating their choices to the other group? In fact, during the first phase when the designers had to understand the demand and appropriate the graphic elements that they had been given, the aside, in this case, was beneficial. This moment enabled them more felt by group A, who remained passive, to agree on the feeling between them before beginning to work with group B that was geographically separated. Nevertheless, these moments must remain, in their opinion, very short to not destabilize the communication and cause a de-synchronisation in the joining of choices. This phenomenon was felt more strongly by group A, who remained passive, during phase 2 when group B, acting directly on the tool, went aside and worked without trying to interact with the others. Two types of use of the tool are to be distinguished: passive and active. From the moment of this observation, a hypothesis needed to be developed according to which a correlation is established between the two elements of time and interaction that we reformulate in the following diagram. The farther we go in the project, the more the users get involved in a collective effort of collaborative design. According to the users, a collective effort of mutual understanding is indispensable to assure the balance in the interaction and avoid destabilization of the interaction.

As for the instrumentation of the collaborative activity, the diagram shows us that the transmission of an idea can only be done through the active use of the tool once the actors are engaged in collective designing.

Consequently, it is important to reduce as far as possible the inter-team asides to succeed in transmitting one's ideas during all of the collaboration. Even if, during phase 6, this aside served the project. In fact, group A began to work on the plan and to propose a new arrangement relating to what group B was drawing on HIS. Here, the complementarity of the two tools directly served the design because two drawings emerged in parallel from two different viewpoints. One served the creation by simulation in 3D (via HIS), the other served the validation by putting the arrangements back on the 2D plan and checking that what was proposed in 3D does not contradict with the general organisation of the space in 2D (via SketSha). In the same way, group A emphasized the importance of not only synchronous, but perhaps simultaneous use of the two tools via two connected tablets: one for SketSha, the other for the space of HIS drawing.

VI. AN ADJUSTMENT PRACTICE

The results in this section focus more on the quantitative analysis of the sequence we selected for the study of the switchover from one tool to another.

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 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" [20]. 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 [21].

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.

"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 proces

Based on quantitative data from codings, we correlated, in entire process, the specificity of time and occurrence of three categories: "looking" (in Figure 9), "drawing" (in Figure 10) and "working together" (in Figure 11). 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.

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.

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.

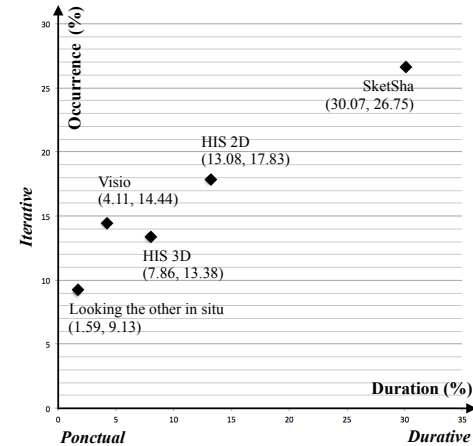


Figure 9. Correlation time/occurrence for "looking" (%).

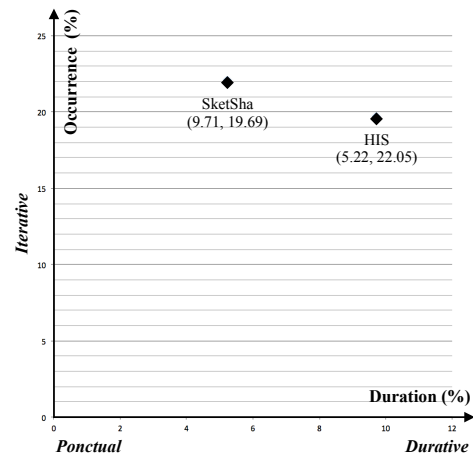
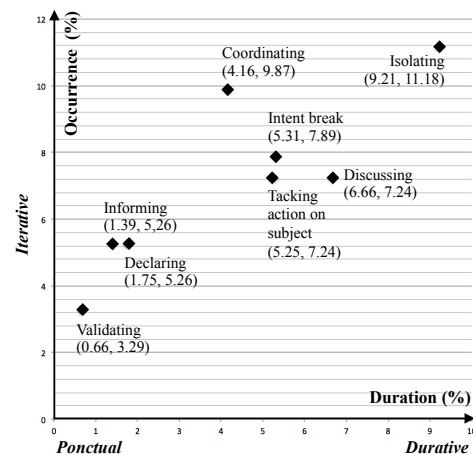


Figure 10. Correlation time/occurrence for "drawing" (%).



	Validating	Informing	Declaring	Coordinating	Tacking 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
% Occurrence	3,29	5,26	5,26	9,87	7,24	7,89	7,24	11,18	42,76

Figure 11. Correlation time/occurrence for " Collective operation for design " (%).

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. 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.

Therefore, considering 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.

VII. 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] S. Ben Rajeb, S. Shirkhodaei, and P. Leclercq, "Time, Occurrence and Switching, Appropriation of two tools in collaborative design Point of view of aspectualization", proceedings of the Seventh International Conference on Advanced Collaborative Networks, Systems and Applications, COLLA'17, Nice, France, 2017.
- [2] 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.
- [3] <http://www.hybridlab.umontreal.ca/his.php?l=fr>, last access in April 2017.
- [4] 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.
- [5] http://www.sketsha.be/F11_Innovation.html, last access in May 2017.
- [6] J. G. Breslin, "Social Semantic Information Spaces", in *Semantic Digital Libraries*, pp. 55-70, 2008.
- [7] 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.
- [8] F. Darses, M. Wolff. "How do designers represent to themselves the users' needs?", in *Applied Ergonomics*, 37 (6), pp. 757-764, 2006.
- [9] 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.
- [10] P. Carlile, "Transferring, translating and transforming: an integrative framework for managing knowledge across boundaries", in *Organization Science*, 15, pp. 555-568, 2004.
- [11] 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.
- [12] 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.
- [13] J. Fontanille, *Le discours aspectualisé*, PULIM, Limoges, 1991.
- [14] J. Holt, *Etude d'aspect*. (translated by "Aspect studies"), Acte Julandicia. 15: 2 Copenhagen, 1942.
- [15] J. Dubois, M. Giacomo, L. Guespin, Ch. Marcellesi, J.B., Marcellesi, and J.P. Mével, *Grand Dictionnaire de linguistique et des sciences du langage*, (translated by "Dictionary of Linguistics and Language Science"), Paris, Larousse, 2007.
- [16] D. Bertrand, *Précis de sémiotique littéraire* (translated by "Literary semiotics"), Paris, HER, 2000.
- [17] S. Ben Rajeb, "Modélisation de la collaboration distante dans les pratiques de conception architecturale: Caractérisation des opérations cognitives en conception collaborative instrumentée". PhD thesis in architecture. Laboratoire Modélisations pour l'Assistance à l'Activité Cognitive de la Conception (MAP-MAACC de UMR MAP CNRS 3495), Université Paris-Est et Ecole Nationale d'Architecture de Paris La Villette, Paris, France, 2012.
- [18] S. Ben Rajeb, "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.
- [19] S. Ben Rajeb and P. Leclercq, "Instrumented analysis method for collaboration activities", proceedings of the Fifth International Conference on Advanced Collaborative Networks, Systems and Applications, COLLA'15, San Julian, Malta, 2015.
- [20] 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.
- [21] 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.) in *Design Computing and Cognition 2008*, proceedings of the Third International Conference on Design Computing and Cognition, Atlanta, USA, pp. 283-302. Springer, 2008.