"SketSha" - the Sketch Power to Support Collaborative Design.

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Abstract. This paper presents a new supporting tool for distant collaborative design, named SketSha. This prototype supports the early stages of design and more particularly the initial and crucial step of free-hand sketching. SketSha and its particular interface, named the virtual desktop, aim to keep from Front-To-Front collaborative work all the benefits and to appoint to them some of the nowadays IT facilities, in order to manage in a realistic and efficient way a long distance collaboration and to effectively serve the designers' needs. Our hope is to re-introduce the social aspects and group interactions, crucial for real system efficacy and adaptation to the business world. The paper presents the fundamental assumptions made to implement SketSha, that are questioned and analyzed through a real-size experimentation featuring 30 architecture and building engineering students, working together in real-time in different locations (Belgium and France). This experiment and the necessary survey open up interesting fields of investigations, such as the relevance of the sketch stage and the proposed device to support distant collaborative design in architecture and the benefit it represents for students, in a pedagogical point of view, to merge the IT aspects and the design studio. The methodology and the replicability are analyzed to increase the level and quality of our students' formation and, finally, a critic of SketSha constitutes a benefit for the developing teams.

Keywords: Distant and Synchronous Collaborative Design, Architecture support device, Sketches support tool.

1 Introduction

This paper focuses on one of the greatest current challenges in the field of design : remote collaborative design. Indeed, the number of actors constantly increases, as well as the quantity of information, the multiplicity of constraints and aspects introduced in the problem definition. All these issues, added to the relocation of skills, made collaboration becoming increasingly complex and imply that a new form of supporting tool is required in order to streamline the process.

These Computer Aided Design tools have to help the designers to collaborate in a natural and intuitive way, without diverting them from their creative task as it is still too often the case. Indeed, although CAD tools offer to architects, engineers and

designers new possibilities (they are obviously extremely efficient in various domains as post-production, rapid prototyping, 3D realistic or even photo-realistic renderings), they still present a limited ability to support designers in their early creative steps. This limitation is explained by (i) the necessity to encode entirely predefined models, opposed to the vague and implicit representations generated during the creative activity, and (ii) by the recourse to declarative WIMP operating methods (Window, Icon, Menu, Pointing Device interaction), imposed by interfaces that don't match the designers' spontaneous ways of expression [8]. These tools might even deform the mechanism of thought, to the extent of negatively affect the inventiveness of their propositions [14].

2 Sketches as Powerful Collaboration Tool

In this context, facing the same difficulties, we propose the initial and crucial step of free-hand sketching as a powerful way to support long distant collaboration.

The free-hand drawing stage is not trivial : the better business decisions, in domains where innovative design constitutes a single little part of the whole process (as for instance building or naval engineering, architecture, industrial design or town planning), are often quickly drawn on a napkin corner ! Many authors grant to the upstream sketching phase the biggest magnitude : it allows the designer to assess some of the blurred mental images s/he makes of the artifact to produce [15] ; it lightens the visual and spatial memory load, freeing up cognitive resources better used in maintaining a dynamic exchange with the drawing, proper to go on with the problem space exploration, till the convergence to a problem-solution pair which could be considered as satisfactory; it enhances creativity, and on top of that it eases the artifact communication [2].

This sketch stage has already been considered to support the collaborative and distant design tasks. One of the precursor prototype is the Electronic cocktail Napkin Sketch [4]. SketchboX [12] is another attempt : this tool proposes to annotate drawings and 3D views or to change some aspects of these (color, texture, ...), these views being finally a "reexamined" background, where evaluation and modification leave a few space to design and creativity. C-Sketch [10] or Fan works [3] also open interesting new fields of investigations, but generally speaking the interactive and synchronous side of collaboration is less exploited.

Yet, sketches have often been proved meaningless out of their context [13; 1] : if used as a support to collaborative design, they shouldn't be taken apart from the social context. Engraved in every kind of collaboration, the interactive aspects such as compromises, argumentation, leadership, stay very important for the dynamic of the group and the quality of the collaboration (but are sometimes neglected at the profit of technics development [6]). As a matter of fact, Gül and Maher observed that, in Front-To-Front conditions, where this social aspect is preserved, designers proposed more ideas, concepts and alternatives than in long distant asynchronous collaborations, that inevitably and obviously provoke delays, misunderstanding, hazardous interpretations, loss of documents and coordination problems [5].

The optimal conditions of collaborative work in this context would consequently be to keep from the Front-To-Front interaction all the benefits (social interaction, real time discussion, real-time idea sharing and generation, ...) and to add to them the software facilities of a sketch support system.

3 Experimental Objectives

In this context, guided by the progress that some of the above-mentioned studios have brought to the field of distant collaboration in the particular domain of preliminary design, our project tends to :

1) support free-hand sketches, drawn in real-time from distant locations on a shared work space, in order to create the best conditions for effective collaborative design;
2) propose to designers a way to sketch that would be as near as possible of the natural way to draw in Front-To-Front on a shared sheet of paper;
3) provide the awareness of other participants : the experiment should provide real-time overall and multimodal view of the interaction ;
4) on a pedagogical side, to constitute a learning tool to afford our students to develop several new abilities, like for instance :

- to understand the common work organization and social connections in between the different actors of a group through a project oriented task ;
- to work on a project that integrates constraints and characteristics that are close from real conditions of work ;
- to understand, acquire and apply the front-to-front and distant methodologies of collaboration;
- to be able to describe and plan collective tasks;
- to get familiarized with a few communication platforms and to communication technologies (synchronous and asynchronous);
- to be able to cast a critic glance to the whole process, tools and technologies and what they are able to offer.

4 Specifications

Given these objectives, the Lucid Group (Lab for User Cognition and Innovative Design – University of Liège, Belgium) has developed SketSha (for Sketch-Sharing), a new tool for collaborative design.

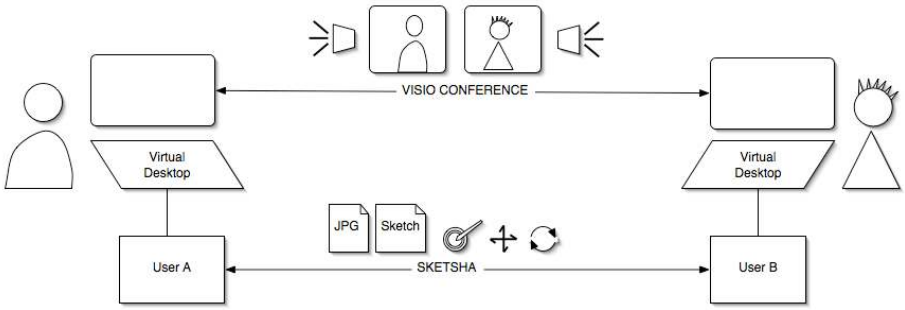


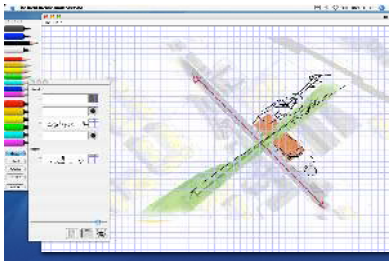
Fig. 1. SketSha operating diagram.

SketSha, very easy to use and requiring a very short adaptation time, is implemented on active boards coupled to a visio-conference system. This particular environment, named virtual desktop, is based on the absent interface concept [7] : the 122*60 cm work surface is particulary well adapted to sketching collaborative tasks, executed with an electronic pen, the system getting rid of the regular WIMP operating systems.

The active board captures the strokes of the user A, that compose the common sketch. These captured informations are transmitted in real-time on the active board of user B, and this way the whole information is shared between the different posts working together (through a simple internet connection).

SketSha functionalities are simple, in order not to disturb the user from its creative tasks. A panel of colored pens (and an eraser) and a simple navigation widget (zoom, translation, rotation) are proposed through intuitive graphical menus. Several layers of work are available, that can be read in superposition through a transparency tool, that can also be deleted or reproduced, and additional reference material (notes, plans, manuals etc.), generally required to support the collaborative work, can be introduced as reference documents or background data.

Vocal, gestural and visual aspects are also supported. Gestures and pointing acts are picked up through pen recognition (without necessary a contact); visual and oral communications are transmitted through a 24 inches display and an integrated camera, that allows the participants to see and talk to each other in an almost 1/1 scale during a real-time conference. This integrated camera is in fact a very simple way to avoid the deviation of the look when talked to the interlocutor(s), which provide a natural way to draw interlocutor's attention on a specific point.



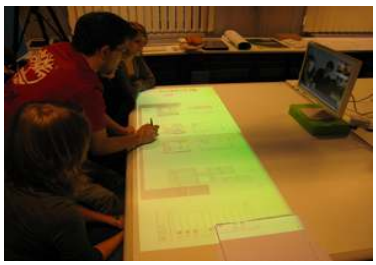


Fig. 2 & 3. Snapshots of the SketSha Interface and of one group in a collaborative session.

5 Research Questions

Implementing this specific tool allow us to firstly adress two main research topics:

1) what is the true effectiveness of this tool in supporting remote collaborative design in a learning environment and which specifications should be retained when undertaking this type of activity ?
2) could the 2D modality be a restrain to creativity ?

6 Modalities of Experimentation

6.1 Architectural Task

The Lucid, the Nancy High School of Architecture (France) and the Tudor Research Center (Luxembourg) cooperate to organize the long distance collaborative studio that could answer the research questions.

About thirty students, 20 in Belgium and 10 in France, worked during one term (3 months, 4 hours a week) on an architecture program.

A virtual desktop device has been installed by the Lab in both institutions for the three months, associated to SketSha and to the whole communication system, so all the components were gathered to create this life-size experimentation. By common assent, a statement was proposed : the students, by groups of 7 (5 students in Belgium, 2 in France), had to conceive a center of environment (3000 m^2), grouping business, research, entertainment and logistic areas. This current consideration of the construction trade is well suited to active share of points of views and constitutes a suitable design framework, executable in a reasonable timeframe. Each student in a group had one predefined role : both the french were the architectural designers (architecture and inner spaces design) and the 5 belgians were building engineers, in charge of a specific domain (energy manager, structure engineer, network and security engineer, environmental quality manager and daylight system designer).

6.2 Process Management

The collaborative process was organized in five phases.

The first consisted of a meeting day for the formation of teams and the site visit to Nancy. The second phase, conducted remotely, enabled students to work together using current methods (email, phone, chat, webcam, web document server…) as well as SketSha, accessible to them once a week for short exchanges (20 to 30 minutes). This required a strict organization of collaboration times each week: agendas and activity reports were required in order to effectively monitor the work and organize efficient virtual meetings. The students were also invited to work horizontally: all the

participants performing the same role could meet to lay down the foundations of their tasks within each group. On top of that, theoretic lectures were proposed to the students to better apprehend the complexity of collaboration. The third phase consisted of an interim evaluation of progress reports, presented remotely, in real time by each team (the students in each group were in different geographic locations). The fourth phase rolled out in a different manner: the SketSha device was accessible by appointment only, for longer periods (up to 1.5 hours), allowing for longer real-time exchanges.

The fifth phase concluded the experiment through a final presentation during the second face to face encounter of the groups, this time in Liège. Students were asked to submit, first off, their architectural proposal (concepts, environmental choices, global organization, technical solutions proposed) and, secondly, to take a critical look at the progress of their collaboration, the design process involved and the effectiveness of the tools available to them. At year end, an educational assessment was available to all students in the form of a written questionnaire, which could be answered anonymously. This assessment provided interesting responses and feedback around the research questions that underlie the entire project.

Fig. 4. Process in Five Stages.

7 Observations and Discussion

The experiment proved a success on several levels, both in terms of the architectural quality of the projects and the level of satisfaction experienced by the students and the support staff during the three months learning experience. Attesting to this success, the observations performed were primarily qualitative: the long term conception phase, involving multiple participants, meant that it was not possible to monitor the entire collaborative process of each group. We therefore assessed the feedback that was presented in the contents of the final presentations (quality of the project, feasibility and innovation) and the conclusive educational analysis of the summary (critical analysis of the experience).

7.1 Organization and Replicability.

The following aspects are discussed with the aim of finding ways to allow for more efficient replicability and the creation of better suited working conditions.

Although typically real-life collaborative projects are undertaken by large groups of participants, the average test group size of 7 or 8 students was too large.

Inexperienced students involved in the research lacked the ability to reassure their teammates about the value of their proposals (especially in technical pre-planning stages). This has proven that overly large groups limit the relevance and quality of information exchange (as already observed in [11]). In the future, groups of 4 members would be more appropriate within this context.

The results of the survey also pointed out the importance of the first day site meeting. It enabled students not only to get to know each other but also to choose their own team without any constraints. As a result, the social aspect has definitely improved: students from the different locations remain in contact several months after the experiment.

Students highlighted the lack of time for working on SketSha as being a problem. The second work phase, where electronic exchange sessions were short, did not allow for in depth collaboration nor time to debate opinions: it was too short for the architects to present the numerous modifications made from one week to another, and too short for the engineers to get involved in the design process. In contrast, the fourth phase, that featured longer access to SketSha, proved to be much more constructive. We noted, however, that work periods exceeding 1.5 hours were somewhat lacking in quality.

Finally, one last aspect to be considered for optimal reproduction is the time required to get familiar the tools. Despite the degree of ease they offer, they are new compared to conventional design tools. The consideration of a period of acclimatization is therefore crucial in order to avoid the bias brought about by time spent on self-teaching of the new tools.

7.2 The Relevance of this Type of Tool to Support Long Distance Collaboration (in Architecture)

The proposed collaboration and its context have enabled students to realize the difficulties involved in a collaboration project, like the compromises needed for a project to rollout efficiently, priorities to be kept in mind, the shift from individual needs to those of the group, one's personal work serving the interest of the group. The students were pleased with the added value that the remote collaborative studio brings to their experience, including the multidisciplinary exchange, the learning of new tools and methods and the amount of organization and accountability they were responsible for.

During the collaboration, the different points of views were often better made clear thanks to little sketches, and the possibility to draw in real-time, on the same virtual sheet, was greatly appreciated. The fact to sit in « front-to-front » conditions also eases communication by allowing informal exchanges, and a "group feeling" quickly grews that made the design easier to manage.

SketSha and its environment consequently seems to globally match the users needs, and this way, the experimentation has offered to the students an original approach of collaborative tasks, as they will for sure be confronted to during their careers.

7.3 Critic of SketSha

The survey has provided highly constructive feedback to the lab on the use of this tool. The digital table, paired with the sketching software, is confirmed as a tool for rapid and simple collaboration, offering several advantages over pen and paper tools, such as the possibilities of sharing, manipulation, the introduction of overlays, etc.

Adversely, some technological difficulties were pointed out, such as the limitation due to share of only one electronic pen available at each location, or the random overloading of the internet network, interfering in the videoconferencing.

7.4 Collaboration in Architecture Supported by a 2D Representation

One of the implementation's biggest assumptions was that the collaborative work would principally and efficiently occur in 2D. This assumption matches some recent research, for instance the Gül and Maher one that showed that 3D work, because of its cognitive heaviness of manipulations and the maladjustment of its external representations to the ones designers really manage, doesn't match the user's needs [5]. The available cognitive charge is indeed consumed by these parallel considerations, while a 2D environment eases the whole process by avoiding these ones. In comparison to the 2D work, the number of propositions decreases, the results are less complete to the benefit of an huge effort realized on a visual rendering [9].

Our experimental modalities and our first qualitative observations don't scientifically afford us to assert that the 2D environment is really the best way to efficiently support a collaborative design, but the results of one of the four groups participating encourage us in this way. The results obtained are indeed deeper, more resulted, maybe less complicated visually speaking but also more detailed and reflected over since technical integrated solutions are considered. It proves that, in a certain way, the use of the 2D modality doesn't, as far as architects are concerned, restrain creativity.

8 Conclusions and Perspectives

The impressive architectural results as well as the quality of the collaborative process understanding that the students showed through their final presentation comfort us about the fact that the experiment was a success on several aspects. First it shows that this type of software prototype coupled with an adapted environment could indeed really support distant collaborative design and help users to face and manage the numerous difficulties of such a task. The benefits for students are clear, on a personal point of view or on a professional one, and the benefit for the Lucid Group, as developing team, is maybe even higher. The pointed observations gathered in the survey, far from having the conceit to constitute unquestionable numerical data, help the prototype designers to complete it and to go ahead with the concept of collaboration supported through sketches, in a 2D virtual world.

The technological limitations will also be regulated and new device extensions open the possibility of further experimentations about the hardware setup, like allowing simultaneously the use of two electronic pens or integrating hand tracking.

In conclusion, this educational study confirms the relevance of sketch tools dedicated to remote collaboration in a formative design context. It paves the way for numerous explorative opportunities, such as the analysis of the collaborative action's 'traces' recorded by the system. These traces will allow us to gain insight into the collective cognitive processes at play. We will not fail to investigate this issue during the next session of Distant Collaborative Studio, already scheduled for 2008-2009.

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