DCDS – Distant Collaborative Design Studio

An Initial experimentation in 'Distant Collaborative Design Studio' in Architecture

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Abstract. *This paper introduces new supporting tools in the field of distant collaborative design, namely DCDS and CRTI-weB. These prototypes respectively support: the early stages of design, through the support of the crucial initial step of free-hand sketches shared in real-time, and the asynchronous collaborative activities. The main goal of this paper is to propose the use of these innovative tools as an efficient and realistic way of managing long distance collaboration, to effectively serve the designers' needs. This proposition is analyzed and addressed through a real-size experiment featuring 30 architecture and architectural-engineering students, working together in real-time at different locations (Belgium and France). This experiment and the necessary survey open up interesting fields of investigation, such as the relevance of the proposed services in supporting distant collaborative design in architecture and the benefit this represents for students to merge the IT aspects and the design studio. The methodology and the replicability are analyzed to increase the level and quality of formation of our students and, finally, a criticism of the tools confirms a benefit for the developing teams.*
Keywords: *Distant collaborative design; sketch support systems; asynchronous collaborative activities.*

Introduction

This paper focuses on one of the greatest current challenges in the field of conception and design: remote collaborative design. The diverse locations of resources and skills, the multi-disciplinary nature of the projects, the varying skills of team members and the amount of paperwork required, all imply that a new form of collaboration is required in order to streamline the process. With collaborative design work becoming increasingly complex, designers must be braced for the future, able and equipped to manage a collaborative work methodology.

In this context, the University of Liège (B), the

Henri Tudor Public Research Centre Henri Tudor (L) and the National School of Architecture of Nancy (F) have jointly proposed to their student engineer-architects and architects, to initiate and run a real-scale 'Distant Collaborative Studio' over a period of three months.

After revisiting previous studies of collaborative design, this article will present the educational objectives of the project, the innovative tools used for the experiment and the methodology implemented.

A detailed observation of the collaborative conditions will be undertaken, where the effectiveness of the available tools will be critically evaluated. Finally, we will attempt to identify the specifications required for a device that efficiently guides and supports the design and conceptualisation within the context of architectural design collaboration.

Remote Design Collaboration Studios

The introduction of remote collaborative design studios in student coursework is fairly recent. In the period following the introduction of the internet, the first modules of CSCW Computer Supported Cooperative Work focused on the introduction of technologies such as VRML, rapid prototyping or knowledge or documentation systems (Achten, 2002).

Other Design Studios address specific cooperation-related aspects of collective projects: the scenarios required for building project-teams, with a view to building trust relationships, particularly between geographically remote students (Cheng 1998; Donath et al. 1999); the role-distribution approach between students and the pedagogical ways to improve it (Van Leeuwen et al. 2005) or the cross-disciplinary approaches, placing an 'AEC expert' in the need to cooperate with others (Fruchter et al. 2007).

Finally, experiments in co-design have also been undertaken in virtual contexts, such as the landmark experiment in 3D/immersive Internet environments, experimentation on virtual collaboration and interaction (Brown et al., 2001).

Experimental Objectives

Guided by the progress that some of the above-mentioned studios have brought to the field of remote collaborative design, our experience suggests the following three objectives:

- To provide the students with a collaborative design work environment that is efficient in both its methodology and technological implementation.
- To place students in a realistic architectural design collaborative environment where they are required to work with architectural software that favours interdisciplinarity and shared decision-making.
- To provide a platform for students to assess and criticize the tasks that they have carried out.

Working Hypotheses

These objectives correspond with numerous working hypotheses of which a number of aspects have been validated in previous experiments, under different conditions, such as the effectiveness of free-hand sketches to support the creative phases of a design; or the ability of a working environment to accommodate architectural design's specific needs (Darses et al, 2008).

Operational Effectiveness of Collaboration

The collaborative device needs to be able to support synchronous exchanges, in both directions, in real time. It has been proven that when design work has been conducted face-to-face, designers put forward more suggestions around ideas, concepts and alternatives than at a distance (Gül & Maher, 2006). The increased ease of information sharing and the lack of interruptions within the design process caused by the interface are clearly the reason. Such a device must preserve the social aspect of any collaboration often neglected due to a focus on technology (Hamid, 2007).

Asynchronous tasks should be equally considered in a long-term work context (in this case, 3 months). These tasks consist of personal contributions towards the design, document management and work-flow coordination, as well as presentation documentation. Though essential to the project's progress and individual expression, they require voluntary participation from the team members.

Effective architectural design collaboration also involves supporting preliminary design phases. Real-time collaborative freehand sketch is always at the core of rich ideas interactions and an ideal support for preliminary design phases.

Many authors concur that this sketching phase has many advantages, setting the entire production process in motion: it enables designers to plot out their mental images of the end product artifact on paper. Sketching out their ideas on paper frees up visual and spatial memory (Gero & Bonnardel, 2005) allowing for the continuation of dynamic idea exchange which enables better problem-space exploration (Cross, 2000). The pencil-paper approach remains the preferred means of collaboration with the architectural studio.

A Realistic Collaboration Situation

The collaborative situation must help students to better understand the collaborative work structure as well as social interactions between group members, to acquire and apply the collaboration methodology. This means:

- Putting together an architectural program adapted to the current considerations of the construction trade - we opted for a program incorporating the key concepts of sustainable development.
- Dividing students into multidisciplinary and multicultural teams.
- Putting together a consistent and suitable design framework: the expected work must be executable in a reasonable timeframe.

Critical analysis of the collaborative design task

Any educational context goes hand-in-hand with critical feedback on the accomplished tasks. Students will be asked to:

- Firstly, work on defining and implementing an established collaboration methodology, that will give structure to the progress of their work and their observations: schedules, reports, feedback…
- Secondly, to post-analyse these collaborative processes, and to present the findings in terms of successes, failures and lessons learnt.
- Finally to answer a questionnaire where they will share their personal views on the collaborative process.

It is indeed enriching for students as well as development and support teams, to critically examine the methods and technologies that have been employed.

Tools Made Available

Given these objectives and the working hypotheses derived from them, two additional innovative tools have been made available for the students' use: DCDS and CRTI-weB.

DCDS - the Distant Collaborative Design Studio

This real-time, shared environment sketch support and exchange device, supports the synchronous aspects of the project. Building on from earlier software proposals, such as NetDraw (Qian & Gross, 1999) or SketchboX (Stellingwerff, 1999), DCSC targets creative support. It has thus been developed in order to:

- present working conditions for remote participants that equate to working in the same space, by providing a large drawing surface whereby remote users can work 'face-to-face' and share their documents in real time;
- recreate social awareness conditions by transmitting voice and visual gestures and exchanges

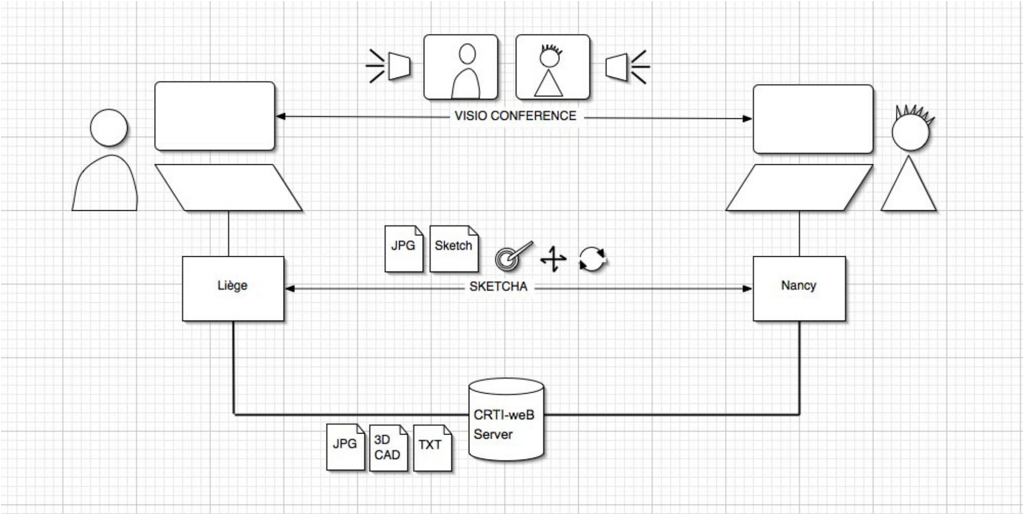

Figure 1
Software architecture diagram

that bring about the social interaction necessary for collaboration: a videoconference system runs on 24-inch screens with integrated cameras, this system means a participant can see their remote team member practically in full size;

- allow users to draw freely: taking advantage of drawing opportunities offered by electronic pen technology, DCSC functionality includes a pencil palette, layer-management and navigation tools (zoom, translation, rotation) that are easy to understand thanks to an intuitive interface; it also supports the importing of any document used as an overlay (images and text can be integrated into the common workspace).

CRTI-weB platform

This tool supports the asynchronous collaborative activities. « CRTI-weB Document Management» is a Web platform developed by the Public Research Centre Henri Tudor in Luxembourg. The basic hypotheses were that most of the existing document management tools are designed to support generic cooperative processes. Their slow-appropriation by architectural and construction practitioners is probably due to the fact that they do not fit the specificities of architectural projects (i.e. heterogeneous participants, short-duration project periods, low-predictable and low-repeatable processes). The « CRTI-weB Document Management » tool aims to offer the essential functions for document exchange in coherence with the specificities and the semantics of cooperative design activities (Kubicki et al., 2007).

It consists of a shared project space that can be accessed by all the participants of a project, through a computer connected to the Internet. It allows the project's members to upload the documents that they produce in the design-phase of an architectural project, and to share them with other team members. The aim is to centralize the documents and to track and trace their updates and modifications. Moreover it's functionality also enables users to be notified when a document is available, and to assign tasks (requests), such as validation tasks or feedback requests. The feedback functionality is a real-time 'discussion forum' open to project members discussing a specific document.

Research Questions

When implementing these specific tools, the proposed experiment allows us to firstly address several research topics:

- what is the true effectiveness of these tools in supporting remote collaborative architectural design and which specifications should be retained when undertaking this type of activity?
- which modifications to the work practices will arise from the collaborative process?

Modalities of Experimentation

Architectural program and support

Students were tasked with conceptualising an 'environment centre': this challenge corresponds with current typical issues and encourages the exchange of views and knowledge. Starting with an existing site, a former industrial wasteland in regeneration, and a description of the required functions and services, each group had to put forward an eco centre designed over an area of 3000m2.

Twenty students from Liège (architectural-engineers) took part in the program, spending 4 hours per week on the project, while a dozen students from Nancy (architects) put in 8 hours per week.

The support was voluntarily reduced. This required that the students structure their own organisation, that they master the complexity and purpose of the task and develop and adapt their working methods. The supervisors were on hand for any questions, beyond the theoretical courses which covered the broad principles of collaboration: adhocracy, hierarchy and cross-discipline in human organisations.

Group Structure

The multidisciplinary approach was embodied by the mixed group structure: team sizes were relatively large (7 to 8 students), this meant that each student was assigned a specific, independent role. The students from Nancy (architects) were assigned the roles of (1) general architectural composition and (2) interior design and supervision of exchanges. The Liège students (architects-engineers) were assigned the following missions: (3) environmental quality and materials, (4) natural and artificial lighting and energy consumption, (5) geotechnical and structural design, (6) technical networks and security, (7) energy management and construction technology.

This division of roles promotes accountability and imitates the conditions of actual project work. Such collaboration, known as 'exclusive' (Maher & al, 1997) is known for the quality of products that result from it.

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 at Nancy.

The second phase, conducted remotely, not only enabled students to work together using current methods (email, phone, chat, webcam,…) but above all to use the CRTI-weB document server. The DCDS system was 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

Figure 2
Process in Five Stages

the same role could meet to lay down the foundations of their tasks within each group.

The third phase consisted of an intermediate 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 DCDS device was accessible by appointment only, for longer periods (up to1.5 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 answers and feedback around the research questions that underlie the entire project.

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).

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. In the future, groups of 4 members would be more appropriate within this context.

The results of the survey also highlighted 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 DCDS 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. In contrast, the fourth phase, that featured longer access to the DCDS, 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 with the tools. Despite the degree of ease they offer, they are new compared to conventional design tools.

Concerning the CRTI-weB tool, its use is closely linked to a re-thinking of classical practices related to document exchanges. The setup of a standard filename for project documents or the design of validation flows between participants inevitably featured IT support services that users have to understand and learn.

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.

Relevance of the tools

The survey has provided highly constructive feedback to the research laboratories on the use of these tools.

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 waiting period experienced due to the need to share the only electronic pen available at each location, or the random overloading of the internet network, interfering in the videoconferencing.

In terms of improvement, students suggested the idea of integrating a discussion forum or a chat service in the CRTI-weB server. The notification function was also criticized the customization options will require improvement. Another interesting idea has emerged; it consists of integrating the two tools that will offer new possibilities such as importing a document directly from the CRTI-weB server to DCDS, or saving a sketch to the CRTI-weB server. This considerable idea will be explored in future shared cooperation between the research laboratories.

Influence of collaboration organisation on working practices

The setup of new rigorous cooperation practices leads to a couple of redundant student criticisms. For instance, the use in the CRTI-weB of standard filenames has been largely contested. This issue was quite hard to comprehend for students who are often unfamiliar with the difficulties related to document exchange between heterogeneous groups of participants in real-life construction projects. But, they agreed that the tool was helping them (i.e. during the upload process the name is checked and in case of a mistake the tool suggests a correct name).

This example is related to the issue of change in working practices, mentioned in the second research topic. In this didactic experiment, students are engaged in a collaborative work which is quite different from most of their previous university projects. Geographical and time distances require a clear and accessible work-flow organization. The setup of a collaboration process (i.e. the tasks to perform, the documents to produce), with the students, has been a valuable step. While each design project is unique, its designers are too and the social relationships between them are of huge importance. That's why we believe that the initial face-to-face on-site meeting is essential to initiate inter-human relationships amongst the group.

Conclusion and Prospects

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.

The experiment has provided the team with answers around the methodology as well as clues on how to take our considerations on remote collaborative design implementation further. Some of the difficulties that have arisen can be solved by adapting the protocol in a number of ways. For example, the limiting of an engineering student to the role of an evaluator can be avoided by distributing the roles within the 'composition' of each geographic group differently. This commonly experienced bias is explained in the following way: the role of the students from Liège, charged with the more technical aspects of the project, was often reduced to them having to post-analyse the design proposals and put forward their suggested modifications rather than playing an active role in the design process. Separated geographically from the design team, they did not have the time nor access to the necessary documentation required for them to be meaningfully involved in the complex design process.

Going forward, the maximum number of participants will be set at 4 per group for greater efficiency.

Finally, certain logistical and technological limitations are currently being looked into by our team such as: improved layers' management and scaling functionalities, pointing tools, integration of access between CRTI-weB and DCDS, and so on.

In conclusion, this educational study confirms the relevance of 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 Design Studio, already scheduled for 2008-2009.

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