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### ► To cite this version:

Veronika Bolshakova, Franck Besançon, Annie Guerriero, Gilles Halin. Use of a Digital Collaboration Tool for Project Review : A pedagogical experiment with multidisciplinary teams. The 38th eCAADe Conference, Sep 2020, Berlin, Germany. hal-03648403

**HAL Id: hal-03648403**

**<https://hal.science/hal-03648403v1>**

Submitted on 8 Jun 2022

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# Use of a Digital Collaboration Tool for Project Review

## *A pedagogical experiment with multidisciplinary teams*

Veronika Bolshakova<sup>1</sup>, Franck Besançon<sup>2</sup>, Annie Guerriero<sup>3</sup>,  
Gilles Halin<sup>4</sup>

<sup>1</sup>UMR n°3495 Modèles et simulations pour l'Architecture et le Patrimoine Centre de Recherche en Architecture et Ingénierie – MAP-CRAI, École Nationale Supérieure d'Architecture de Nancy – ENSAN; Centre National de la Recherche scientifique – CNRS <sup>2</sup>UMR n°3495 MAP-CRAI, ENSAN <sup>3</sup>Luxembourg Institute of Science and Technology – LIST <sup>4</sup>UMR n°3495 MAP-CRAI, ENSAN; Université de Lorraine <sup>1,2,4</sup>{bolshakova|besancon|halin}@crai.archi.fr <sup>3</sup>annie.guerriero@list.lu

*This paper emphasizes feedback from a pedagogical experiment in the context of teaching collaboration and design to multidisciplinary teams. A digital collaboration tool, a multi-touch table and collaboration software, was used as a support for discussion and decision-making for weekly project review meetings. The experiment participants' feedback on the use and usability of the digital collaboration tool highlights the potential for the use of synchronous collaboration technology and project-based learning for higher-level education. It also highlights the need for a transition towards implementation of digital tools at project review sessions.*

**Keywords:** : *Synchronous collaboration, Pedagogical experiment, Project-based learning, CSCW, NUI, BIM*

## INTRODUCTION

This paper is a part of a research on design and development of a prototype of a new collaborative decision-making tool, which would be well adapted to the AEC professionals needs, BIM workflow and collaboration practices. The development is guided by the user-centered design approach, which implies studies of the user's needs and behaviors.

The paper continues to explore the pedagogical experiment observations, data and feedback analysis that was partially presented in the previous work

(see (Bolshakova et al., 2019)), which presented an overview of the users feedback and session documents from the first 2 phases of the experiment.

To complete the feedback summary, this paper also assists by integrating the lessons learnt into the future pedagogical approach.

The paper aims to: emphasize the feedback from the experiment participants on the use of a digital collaboration table in order to understand the current tool limitations and identify the requirements for future development; to emphasize the pedagogical

ical team feedback on the use of the touch-table for project review.

First, the section Experiment description introduces the pedagogical experiment of a digital collaboration table (DCT) use for synchronous co-located collective project review meetings (digital collaboration session or DCS). The DCT is a system of software: collaboration environment “Shariing” developed by “Immersion”[1]; and of hardware: a PC and a multi-touch screen. In detail, the section describes the pedagogical context and the pedagogical experiment phases, also it provides a short overview of the collaboration tool and sessions.

The following section presents the research questions and tools, and it highlights the relevant to the usability feedback evaluation tools, which are emphasized in this paper in particular.

Next section of the paper summarizes the usability feedback on DCT from the sessions’ participants, and it concludes with the pedagogical team reflection on the DCT use experience.

## **EXPERIMENT DESCRIPTION**

### ***Fostering digital design and collaboration practices in AEC***

Collaboration and collective decision-making at project team meetings is an important part of any construction project development. At the meetings multidisciplinary cooperation and collaboration require an effort from all project participants (Staub-French and Khanzode, 2007).

In addition to the collaboration inside the project team aspect, nowadays digital tools and BIM are the standard for project development (Kensek, 2014). Therefore there is also a need for an efficient and AEC adapted digital collaboration environment (Achten, 2001), for a digital continuity of the workflow (Boje et al., 2019), and for a management of digital coordination in design (Whyte et al., 2008).

Thus, it is important to introduce the future AEC professionals to such collaboration and digital design practices during their studies.

### ***Pedagogical context***

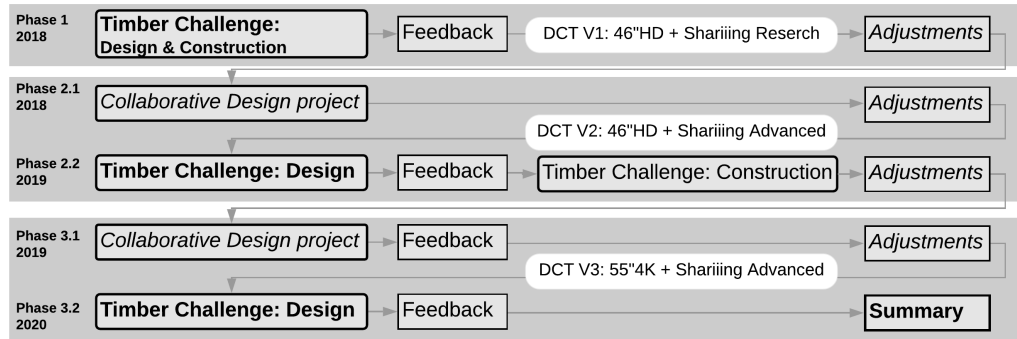
The “Architecture, Timber, Construction” postgraduate program curriculum at ENSTIB (Engineering School of Wood Technologies and Industry) offered a context to the experiment. The students have either architecture, timber or civil engineering background. During the first semester, they work in teams on a Collaborative design project and go to other curriculum classes. During the second semester, they also work in teams, but on Timber Challenge (original French “Défis du Bois”[2]), and follow an internship at architecture or engineering firm.

The subject of a Collaborative design project is usually a housing as the main program with some public buildings in addition. Every student team must design a project in detail, starting with an architecture design, which is further supported by engineering solutions and calculations. The project life-cycle and economic aspects are also in the scope.

Timber Challenge exercise is a project-based learning opportunity (Dunkin, 2000), which is given to 10 student multidisciplinary teams to first design and then construct a wooden microarchitecture project in collaboration. Such an exercise gives a realistic scale to the projects. It strongly encourages students to foresee and avoid problems related to their design choices (Kubiak and Vaculová, 2018), and also pushes students to anticipate construction solutions adapted to their designs and curriculum-related skills.

Presented aspects of these pedagogical exercises shape a favorable context for our observations of collaboration and of collective decision-making with the DCT (Bolshakova et al., 2019). The teams used a digital collaboration tool (a multi-user touch table) with Natural User Interface at weekly project review meetings: digital collaboration sessions.

Figure 1  
Schema of the  
digital collaboration  
experiment steps



### Main phases of the experiment

The research was carried out in three main phases over a three year period ( Figure 1), during each phase the student teams were working with a pedagogical team with DCT. Specifically, in Phase 1, the Step 1 was the Timber Challenge design and construction phases, Step 2 was the collection of the users' feedback and the adjustments to the collaboration sessions. Phase 1's feedback showed the utility of DCT and suggested improvements for the next phase.

In Phase 2.1, as in Step 1, the students were introduced to the work with the DCT in the first semester during the Collaborative design project. The introduction aim was to train all the students to be efficient with the digital collaboration tool during the upcoming Timber Challenge. The next Phase 2.2 started with Step 1 - the Timber Challenge 2019 design phase and feedback collection. It then concluded with Step 2 Timber Challenge 2019 construction and the new adjustments. Phase 3 also had 2 parts, and was strongly based on Phase 2, and it concluded the experiment. In this paper we focus on the DCT use feedback from Phase 3 to complete the knowledge and on pedagogical feedback.

### Digital collaboration table short overview

The DCT in the experiment context was used for co-located synchronous collaboration with a focus on visualization and annotations through NUI interactions for decision-making. The design documents modifications and distant collaboration are not in the scope of the study, even though Shariing provides a function of connection to another distant Shariing.

The DCT's configuration, has evolved through the experiment due to software and touch technology improvements, and also as an answer to the users (professors and students) needs. The evolution can be distinguished through the versions of DCT: V1, V2 and V3 (see Figure 2, Figure 3, Figure 4). Figure 1 illustrates the moments of version implementation during the experiment. The main difference was in: 1.The software versions: V1 - "Shariing Research", V2,3 - "Shariing Advanced"; 2. Screen size and resolution; 3. Touch technology: V1 - infra-red, V2,3 - projected capacitive (see Figure 1). However, the essence of the DCT stayed the same.

Before the session students prepare the relevant documents. They either stock them (2D documents, videos, web-pages) into the cloud which is connected to the DCT, ether they share with the DCT a screen of a laptop through a Shariing connection client if they want to visualize and manipulate a BIM model (see Figure 5).

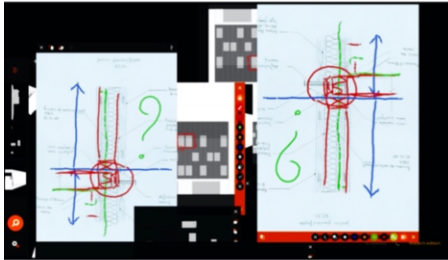


Figure 2  
Collaboration with  
DCT V1: annotation  
of façade detail

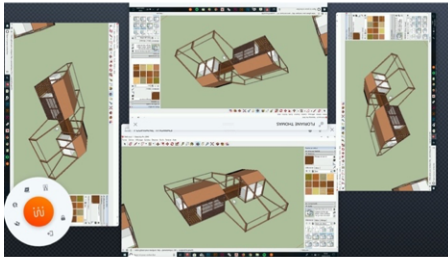


Figure 3  
Collaboration with  
DCT V2:  
interactions with  
3D model shared  
from SketchUp

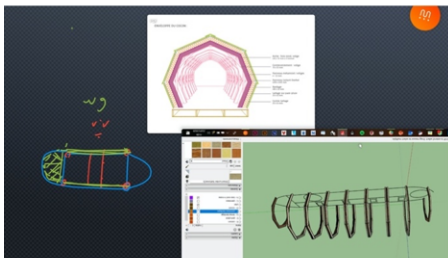
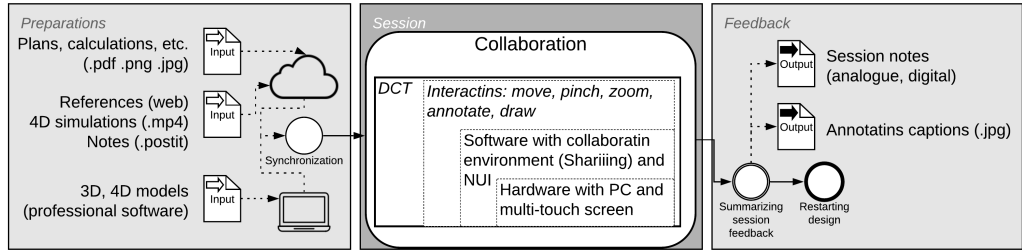


Figure 4  
Collaboration with  
DCT V3: 2D section  
and 3D model  
visualization,  
background  
sketching

Figure 5  
 Schema of the  
 process of  
 synchronization of  
 the documents for  
 the session and  
 session feedback  
 outputs



Thus, when using Shariing Advanced (the latest version of the Shariing software), it is possible to share a view from a BIM viewer or design software (e.g., Archicad, Cardwork, Navisworks, etc.) directly into the Shariing collaboration environment, and to keep the natural interactions and simple annotations, or manipulate the model from the computer used for the view sharing.

In the current configuration, users may only save an annotation (Figure 3) on a project document as a new 2D image - the annotation capture (a screenshot) or draw a quick sketch (Figure 5). Even though such limitations do not ease design modifications, they yet offer to users the tools for a focus on discussion and decisions.

### **Digital collaboration sessions participants and used documents**

The digital collaboration sessions (DCS) were dedicated to the students project progress review and advising. Therefore, in correlation with the project progress, the potential number of DCS was different.

During the more exploratory Phase 1 only 9 users participated at DCS, where 3 users were the members of the pedagogical team and the other 6 were students (2 teams of 3 students) of the "Architecture, Timber, Construction" program. Further, all the program students (in 10 teams of 3/4) were participating: 30 on phase 2, 31 on phase 3.

The professors were the constant members of the curriculum pedagogical team, so they were the same 5 users at Phases 2,3.

Most of the students were already active users of 3D modelling tools, more than 60% of them are using the tools often or all the time. Almost a fifth of the total number of students were familiar with 4D before joining the curriculum. For example, at Phase 3 more than a quarter of students were familiar with 4D.

Students were preparing plans, sections, details, 3D models, 4D simulations and other documents comprising their projects. Most of the sessions without 3D models were based on 2D documents, however, once the project advanced and the 3D of the project was on the table it became a center of discussion. Table 1 summarizes the number of those present at DCS teams and the documents they used.

## **RESEARCH AIMS AND TOOLS**

### **Research scope**

In order to design a collaboration support tool with a well-adapted interface to AEC users, we study the use of DCT by the experiment participants. Certainly, the collaboration workflow corresponds to the project type and project development phase.

Our study focuses on the synchronous collocated collaboration (e.g. meeting) of a project team with DCT. With this paper we cover the following aims of the experiment:

- Evaluate the users' perception of utility and usability of the digital collaboration table and emphasize the advantages and current limits of such a tool;

- Emphasize the lessons learnt from the implementation of the DCT into the pedagogical context.

Also, with DCS observations, we aimed to better portray decision-making and main collaboration dynamics aspects, such as: duration of the session, documents used for discussion, interaction gestures, and decision-making points. Which are in the scope of the study but not of this paper.

### Data collection tools

The users' feedback was collected through an extensive questionnaire filled out by the users and through the semi-guided interviews with student and pedagogical teams.

The questionnaire was comprised of multiple parts to collect information on different subjects (System Usability Score, Team Reflexivity, Technology acceptance, open answer questions and study of 4D BIM uses perception).

To complete users' feedback on the digital collaboration experience and the table, as well as on their team collaboration experience, a series of semi-guided interviews was conducted at the end of the pedagogical exercises. Every student team and the pedagogical team shared their team experience at a recorded interview. The group interview was chosen over an individual one to highlight the team collaboration experience.

Also, the observations of DCS and of users' interactions were assisted with video recordings. The observations and interview results reveal the utility and collate suggestions for improvements to the support, as well as identify the digital document types used for different session activities, covered in a previously published work (see (Bolshakova et al., 2019)).

This paper focuses on the correlation with the System Usability Scale (SUS) scores (Brooke, 1996) and qualitative feedback results from the analysis of interviews (Braun and Clarke, 2006). The pedagogical team presents their feedback on the advantages of DCS.

## USABILITY FEEDBACK SUMMARY

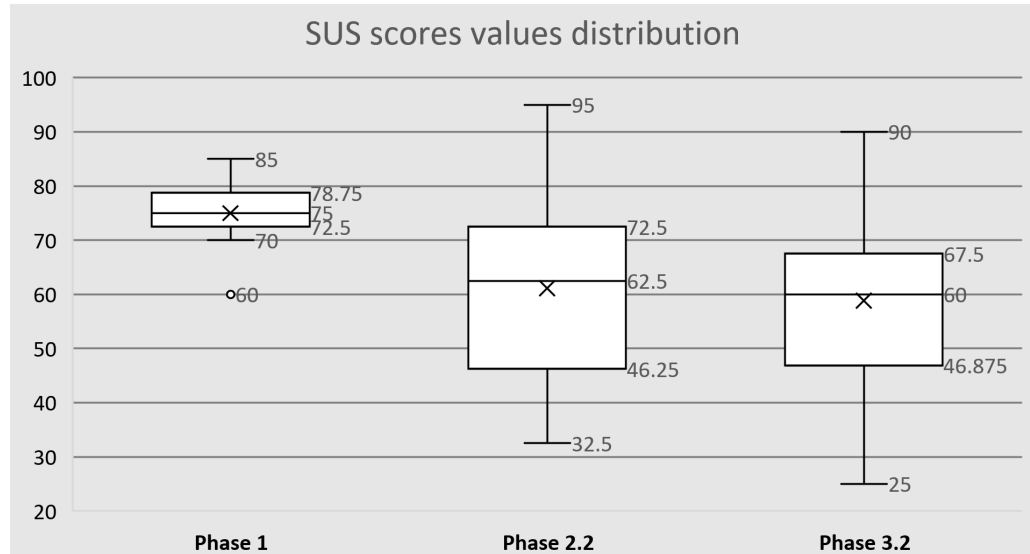
### SUS scores summary

Due to the mixed approach to DCT evaluation by users, the results revealed a variety of user experience aspects with DCT and collaboration. The SUS mean scores from all the user categories together (professors, students: architecture, timber engineering, civil engineering) were 75 for Phase 1, 61 for Phase 2.2, and 60 for Phase 3.2. The methodology of the SUS scores (Brooke, 1996) recommends we interpret these scores as: 75 "Good", 61 "OK", and 60 "OK"; according to a scale from 0 to 100 (percentiles), with a passing range starting from 68 (Brooke, 1996). Figure 6 summarizes the scores.

Phase	Pedagogical exercise	DCS number	Student teams at DCS	Participants		Teams using	
				students	professors	3D	4D
Phase 2018	1 Timber Challenge	3	2	3	2/3	2	1*
Phase 2019	2.2 Timber Challenge	4	10	3	2/3	10	5
Phase 2020	3.2 Timber Challenge	2	10	3	2 or 3	9	0

Table 1  
Summary of DCS teams and documents

Figure 6  
SUS scores values  
for Timber  
Challenges for all  
users together



However, these numbers should be reviewed in detail. For example, the score from Phase 1 is higher, due to the general user profile being “innovation eager and curious about technology”. The next two phases’ scores suggest a larger variety of users’ opinions on the DCT.

Also, SUS scores from the user categories are different; the professors mean is 80, thus suggesting that DCT is “Good” and close to “Excellent”, on the other hand the students mean is 60. Even with the score appearing low, more than 80 % of users confirmed that: in general, with the DCT they could perform their actions well (with no obstacles) during collaboration sessions. The score from those users is 67, which suggests a score rather close to good. Therefore there is a need for an analysis of general acceptance of technology and qualitative feedback.

In addition, the analysis presents a pattern between the number of a user’s years of experience and the score. The users with more than 2 years of experience tend to give higher scores, moreover the active and experienced users of 3D modeling score similarly. Furthermore, the analysis previously showed higher scores from the architects and lower scores from the civil engineers, but the last phase of the experiment did not reveal a particular difference among the scores of those different user backgrounds. However, the study highlighted again that the DCT is most useful to the users with a strong connection to CAD and BIM, and it is also most useful to those who already have several years of experience, as they give better scores.



The future comparison of the SUS scores from the student teams (instead of single users) to both team performance and team collaboration culture would give a better understanding of the DCT's perceived usefulness on the group level. It will portray a collaboration group persona through the team reflexivity and activities analyses. The complex analysis will give directions as improvement teaching multidisciplinary collaboration and contribute to the collaboration tool design.

### **Team collaboration and DCT use**

In addition to the quantitative data, the qualitative data from the student teams gives rather positive feedback. The students state the interactivity and visualization quality as the most interesting aspects of the DCT. They also mention the general "playful curiosity" and "nivelete the student-teacher barrier" aspects as the new experience from the project review meetings.

However, a half of the teams claims that they did not feel fully confident about their use of DCT, even after the first semester introduction and active use of the DCT. The main reason, highlighted during the interviews was "stress and pressure" from the dense rhythm of the DCS and need to collaborate with the other disciplines. The teams with a strong collaboration were producing better designs, therefore felt confident at the DCS and used DCT for their benefit.

### **PEDAGOGICAL TEAM REFLECTION ON THE EXPERIMENTS**

The primary initiator for the experience with the DCT was the pedagogical team. As they have done in the past, the focus was on the student projects rather than the optimization of the DCT use. Because of this, the team was available to provide feedback on DCT usability just as the students were. In addition to the DCT users' feedback, the professors emphasized the pedagogical point of view on DCT implementation into teaching design and construction to multidisciplinary teams. Besides, they have provided reflections on the changes the DCT brings to the design

process, the DCT advantages, disadvantages and reflections on future goals.

### **Augmented participation and interactions**

Since all the users are united around the DCT and are disposing the same project documents, so there is a certain clarity of visualization and democratic natural user interface interactions. The pedagogical team has access and a clear scope of the project state. Before coming to the session to see the professors, first, the students have to cease work on their design processes, then they take time to emphasize the progress and prepare the session documents, and finally students do not stay in front of their computer and are expected to participate at the decision-making.

### **More efficient feedback but lack of emphasis**

Due to the better access to the documents and interactivity, the pedagogical team provides better and more thorough feedback on the students' projects. However the current DCT configuration and the collaboration approach did not offer a hierarchized list of session decisions, nor did it offer easy planning for further development and tasks assignment. Therefore, most of the student teams leave the session with a great deal of unstructured feedback they would not naturally implement efficient collaboration practices. The pedagogical team highlights the need for a change, first, of the session scenario, by adding a few minutes to summarize the decisions and plan the future session with the tools already integrated into the DCT, and second, to provide hands-on experience to students in multidisciplinary collaboration practices and tools.

### **Design with 3D and multidisciplinary teams**

The pedagogical team agrees on one of the main advantages of the DCT, it is the ease of visualization and interactions with 3D and 4D models. Yet, not all the members of the curriculum's multidisciplinary teams are familiar with 3D modeling, therefore the 2D documents are still the core of the early design process.

The 2D provides better communication within the team, gives every member an equal ease of contribution. The DCT provides an interactive aspect to the 2D documents as well, and for now they are used even more often than 3D as a support during discussion, especially in the early stages. However, the pedagogical team has noticed that even a single 3D model for the Timber challenge provides enough information about the project.

The DCT, as a medium of collaboration, fosters new ways of working together, therefore it forces a change of habit for the design practices and need to adapt for the digital collaboration session workflows. The future pedagogical strategy must focus on the development of the digital collaboration culture in the multidisciplinary student teams. So the students would be able to form reflexive efficient teams and adapt to multidisciplinary workflow.

## CONCLUSIONS

With this study, we continue to explore the three years of pedagogical experiment feedback gathered through observations, questionnaires and interviews analysis. The experiment context offered an opportunity to implement a digital collaboration tool for the project review sessions and observe the use of such a tool by multidisciplinary teams.

From the researchers' perspective, the experiment summary contributes to the user-centered design approach of a new collaborative decision-making tool. From the pedagogical perspective, it concludes the pedagogical team reflection on the use of a digital tool and teaching strategies for collaboration.

This paper focus on the System Usability Scale (SUS) scores revealed a correlation between users' appreciation of the digital collaboration table and their years of experience in professional and with CAD and 3D modeling. Also, the feedback from students and professors highlights the need to focus on the reinforcement of collaboration culture inside the team, so the teams would fully benefit from the digital collaboration tool. Implementing and experi-

menting with the collaboration tools during the academic curriculum prepares future professionals for future multidisciplinary collaboration in the industry.

## ACKNOWLEDGEMENTS

This study was developed under the patronage of "Agence Nationale de la Recherche" No.ANR-16-CE10-0006-02 (FR) and "Fonds National de la Recherche" (LU), as a part of 4D Collab research project. Authors acknowledge "Timber Challenge" teams for participation and "Immersion" for technical support.

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[2] <https://www.defisbois.fr/>