Tele-Board in Use: Applying a Digital Whiteboard System in Different Situations and Setups

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Abstract Tele-Board is a digital whiteboard system that helps creative teams working together over geographical and temporal distances. The nature of Tele-Board's synchronized setup allows every connected partner from anywhere in the world to join in the action. Tele-Board is rooted in traditional metaphors, which are easy to implement and come naturally to the user. Additionally, it is possible to follow a common thread in the development of ideas from their inception to conclusion. With the History Browser, the path of creative development can be retraced, reiterated and resumed – from any point in time – a huge benefit in ordering work and reaching conclusions. In this article, we report on several situations and setups in which Tele-Board was used by different teams. We demonstrate how our software suite can be used with various hardware setups and show how well the tools work in practical application. Furthermore, we illustrate Tele-Board use by globally distributed student teams, in remote test settings, during a sustainability conference, and by teams who are primarily used to traditional whiteboards and pen and paper.

1 Creative Work in the Digital World

For global companies it is vital that they regularly come up with new, innovative ideas in order to ensure long-term competitiveness of the organization. With these economic goals in mind, another incentive would be solving inherent problems of this world. If an organization manages to develop products or services that truly

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Fig. 1 Working remotely with the Tele-Board system

support other organizations and improves individuals' lives, the probability of public and economic success grows.

While researchers write more and more books on the inner core of Design Thinking (e.g. Brown 2008; Cross 2007; Lockwood 2009; Martin 2009; Plattner et al. 2009), we focus on tools to support teams who are working in a way, as it is taught e.g. in the School of Design Thinking in Potsdam. While many factors constitute the success of Design Thinking, one of them is its methods' tangibility and easy to use tools that are understood worldwide: paper, pens, whiteboards and different material most of us know from kindergarten.

Problems arise, when continents and time zones separate the team that is working on a problem. With this in mind, we developed the Tele-Board system, which provides the possibility to work creatively over distances and still retains the feeling and working modes of traditional tools (Gumienny et al. 2011). People can work with whiteboards and sticky notes in a way they are used to and additionally have the advantage of digital functions that don't exist in the analog world. For remote settings, all whiteboard actions are synchronized automatically and are applied by every connected partner. Optionally, the teams may include a video conference between themselves and the distributed team: the translucent whiteboard is an overlay on top of the full screen video of the other team members. This setup lets everyone see what the others are doing and which content they are referencing. Additionally, gestures and facial expressions can be seen (see Fig. 1).

Most recently, we focused on testing and deploying Tele-Board in a variety of different situations and contexts. Besides conducting scientific experiments and usability tests, we also provided Tele-Board to teams who were collaborating over distances or made use of digital tools instead of traditional ones.

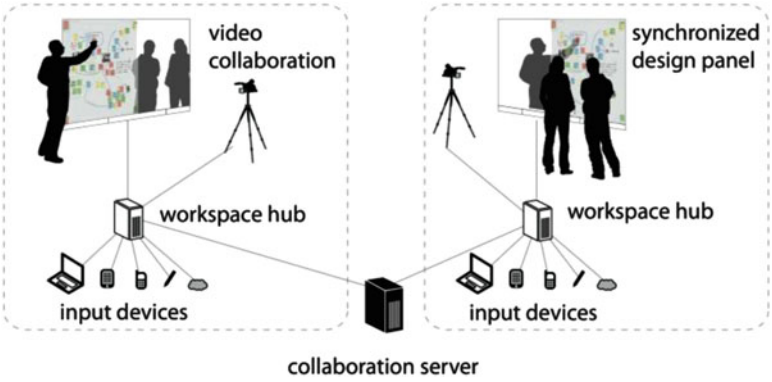

Fig. 2 General setup of the Tele-Board system

In this article, we will present Tele-Board's functions and possibilities with a special focus on different hardware setups depending on the given situation. Following this, we will report on experiences from different usage scenarios and their implications for our work. The next section will give an introduction to the design of the Tele-Board system.

2 Tele-Board: A Flexible System for Remote Collaboration

Tele-Board is a software system that supports remote collaboration based on electronic whiteboards. The interaction with the system works in a similar way to conventional whiteboards, i.e. writing, drawing, and erasing on the whiteboard surface can be done in the usual way. Beyond that, it is possible to create digital sticky notes using the whiteboard or additional input devices such as Tablet-PCs, iPads or smart-phones. At the whiteboard, it is possible to edit sticky notes, move, resize, and generate clusters of them.

Remote collaboration is facilitated by connecting several digital whiteboard devices at their corresponding locations with the help of the Tele-Board system as shown in Fig. 2. All of the actions mentioned above are synchronized automatically and propagated to every connected whiteboard. Every user can manipulate all sticky notes and drawings, no matter who created them. Furthermore, a videoconference feature is included. The whiteboard content can be displayed transparently on top of the full screen video of other team members. Local team members can see the actions and pointing gestures of the remote team members and vice versa, which facilitates an easier and more interactive session. The flexible architecture of the Tele-Board system makes it possible to start the whiteboard software on every computer (for more information see Gumienny et al. (2011)).

The content created with Tele-Board is organized based on *Projects*. A project can be used to embrace all phases of a design process. During the course of a

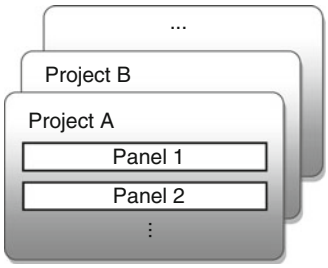

Fig. 3 Organization of Tele-Board content

traditional design project, a set of analog whiteboards is filled with sticky notes and handwriting. In Tele-Board, the digital counterpart of a physical whiteboard is called *Panel*. A panel is displayed with the help of an electronic whiteboard and can be filled with virtual content. The interrelation between panels and projects is depicted in Fig. 3. Every panel is assigned to a single project that in turn can contain an unlimited number of panels. Moreover, panels can be archived and restored to any state during the panel's progress (for more information see Gericke et al. 2010).

2.1 Tele-Board Components

The functionality of the Tele-Board software system is divided among different components, which are as follows:

Web Application: The web application[1] serves as an administration interface enabling users to maintain their projects and associated panels through a web browser. The whiteboard client that allows editing of a panel is started from this interface, what makes the web application the entry point of the Tele-Board system. Furthermore, it is convenient to use because there is no need to install any extra software.

Whiteboard Client: The Tele-Board whiteboard client is a platform-independent Java application. It facilitates whiteboard interaction, e.g. writing with different colors, erasing, and the creation of sticky notes. The client software runs on the user's computer, which can be connected to an electronic whiteboard. Therefore, it is possible to operate the system with any whiteboard hardware, a Tablet-PC or just with a mouse on a computer screen if no electronic whiteboard is available. Additionally, the whiteboard client interacts with the Tele-Board server component by synchronizing with other clients started at a remote location, as depicted in Fig. 4.

[1] http://tele-board.de/

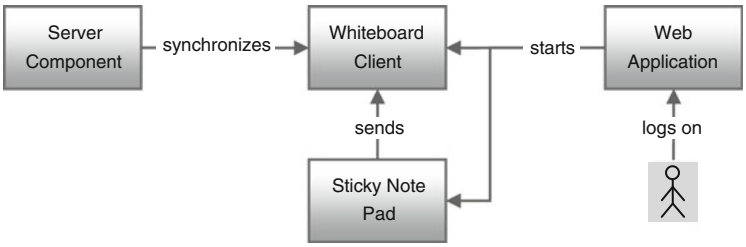

Fig. 4 Tele-Board components and their interrelation

Sticky Note Pad: This component can be used as a dedicated input tool as shown in Fig. 2. To increase flexibility in terms of input variety, we created different applications for writing sticky notes as an equivalent to paper-based sticky note pads. The Sticky Note Pad is well suited for Tablet PCs and other pen input devices. For convenient input from a handheld device you can use the corresponding App on an iPad (StickyPad HD[2]), iPhone or iPod touch (see Fig. 5).

Server Component: The server component coordinates all communication between the remote partners. All interactions are transferred as XMPP messages to keep the connected whiteboards synchronized. For advanced saving and resuming possibilities, we extended the server component with additional functions (see the History section for details).

2.2 Video and a Translucent Whiteboard Surface

Remote collaboration on electronic whiteboards can benefit from an accompanying videoconference showing the remote team interacting with their whiteboard. Without video, whiteboard interactions by remote team members appear as if made by a "ghost hand". For the current implementation, we decided to use Skype because of its proven reliability and ease of use. However, Tele-Board can be used with any third-party videoconferencing software. The whiteboard client can act as a translucent overlay on the video image giving the impression that the remote party is directly interacting with the whiteboard content (see Fig. 1). We also tried out different camera angles, for more information see Gumienny et al. (2011).

[2] http://itunes.apple.com/app/stickypad-hd/id464034808

Fig. 5 iPad running the StickyPad HD app as an input device for Tele-Board

2.3 Tele-Board History

As we learned from user feedback and interviews, people in remote teams very often work asynchronously. To support these working modes, we developed a solution helping team members, who cannot be connected at the same time, to understand what the others were doing and easily hand over their work.

Easy navigation through different whiteboard states and resuming work at any previous point in time is a major goal in our development process. A digital whiteboard solution can also offer the possibility of extensive and partly automated documentation. In traditional whiteboard settings it is time-consuming and troublesome to take detailed photographs after work is done. Written documentation for stakeholders and customers has to be prepared additionally. Another argument for the importance of implicit documentation is the statistical relevance for people researching team behavior and how design over distances and time differences is carried out. Various questions could be answered using the history data: What is the main working time of the employees? How can the output become measurable? Not only design researchers could be interested in this information, but also the designers themselves would profit from gaining insights into key factors of their creative work. The possibilities of the Tele-Board system in terms of the traceability of remote work concerning researchers are shown in Gericke et al. (2011).

The *Tele-Board History* is implemented as a central archive that is used to keep track of all data, make analysis more convenient, and enable asynchronous work. Therefore, communication data handled by the server is stored in a database. This allows the immediate analysis of the communication flow and storage of the real communication data rather than image representations of the content. For more information see Gericke et al. (2010).

Table 1 Variety of hardware in the observed setups

	Whiteboard hardware location one	Whiteboard hardware location two	Sticky note devices
Global student teams (Germany – California)	SMART board interactive display overlay	DELL interactive projector S300wi, rear projection	Laptops
Global student teams (Germany – France)	Luidia eBeam, Hitachi short-throw projector on the ground	DELL interactive projector S300wi, rear projection	Laptops
Logic grid puzzle	SMART interactive board UF45-680	SMART interactive board UF45-680	–
Sustainability congress	Panasonic elite Panaboard T8	Promethean ActivBoard	Three iPads, Laptop
Physical versus virtual boards	SMART interactive board UF45-680	Promethean ActivBoard	–
One day challenge with design thinking students	SMART interactive board UF45-680	SMART interactive display	Four iPads, TabletPC, Digital pen, Laptop

2.4 Flexibility Through Hardware Independence

In an ideal world, all teams, who want to work creatively over distances, would always have the best available hardware at hand: several state-of-the-art interactive whiteboards, different mobile devices for each user and an easy-to-use and reliable audio- and video conferencing system. Of course, in most working environments and situations this is not the case. The equipment is relatively expensive and often bulky, which can make logistics sometimes difficult.

Therefore, we always had hardware independence and flexibility in mind, when we designed Tele-Board. The web portal can be viewed with any browser, even on mobile devices. An installed Java Runtime Environment – as is the case on most computers – is the only requirement to use the whiteboard client. As all interactive whiteboard hardware and display technologies can emulate mouse input to the connected computer, it is possible to use any of them for working with Tele-Board. Of course, some devices behave more precisely or faster than others, but this often goes along with a higher price regarding costs and mobility.

For most situations in which we introduced Tele-Board, we used different hardware equipment – mostly because we had to adapt to the situation and equipment we found. In the following table, an overview of the various setups we used is presented (Table 1).

In the following, we will describe how the different hardware setups affected the teams' way of working and which devices are better suited for a particular situation.

3 Tele-Board in Use: Remote Location Setups

Our main objective during the early days of Tele-Board was the vision to support Design Thinking teams in distributed settings, mainly in the School of Design Thinking in Stanford and Potsdam. In recent years, Design Thinking and similar approaches have found widespread application. That is why we regularly get feedback from people looking for a solution such as Tele-Board. In order to develop an even more elaborate state of the system, we constantly try to use it in all kinds of setups and get feedback with regard to its usability – in addition to the scientific experiments we do for our research.

In the following two sections, we give an overview of what happened when we supplied very different teams with Tele-Board, while looking especially at their working modes and hardware setups. We start with the remote location setups.

3.1 Global Student Projects: The ME310 Course

ME310[3] is a course that has been taught at Stanford University for many years. Student teams work on real world design challenges from corporate partners. Teams of usually six to ten people are given 9 months of time, and the trust to design a complete package of innovation together with a corporate partner. This includes methods such as user observation, brainstorming, prototyping etc.

Over the years, ME310 has become more and more global. Most teams are distributed over the globe, e.g. joint teams of Hasso-Plattner-Institute students in Germany work together with their partner team at Stanford University or ParisTech University in France. Depending on their locations, the teams have very few opportunities for personal meetings together (usually only for kickoff and the final presentations). Meanwhile, these teams are separated across two countries.

In order to help them to communicate and collaborate over distances, we equipped the teams at HPI and ParisTech with interactive whiteboard hardware. In this first pilot year, there was no large budget for equipment and therefore we had to find low-cost setups. At the HPI in Potsdam, students used an interactive projector together with semi-transparent film in a rear projection setup (see Fig. 6, *left*). In Paris, we set up an eBeam system with a short-throw projector on the ground (see Fig. 6, *right*).

Unfortunately, the teams could not really work remotely as there were general problems concerning the Internet connection at ParisTech. So the students decided to have Skype calls at home.

At HPI, the students used Tele-Board for collecting and clustering their user research data, creating personas and brainstorming (see Fig. 7, *left*). They liked the

[3] http://me310.stanford.edu/

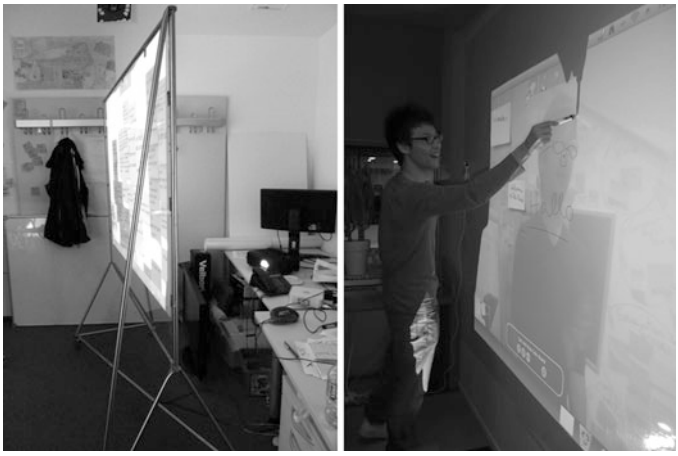

Fig. 6 Setups of the Tele-Board system for the global students project ME310 between Potsdam, Germany (*left*) and Paris, France (*right*)

possibility to easily add pictures and notes to the board and open it on any computer, not only at the office. However, they were missing a tool to easily draw sticky notes as our Sticky Pad App was still under development. They said that the "pen" of the interactive projector was too big and heavy for really using it on the whiteboard and therefore they did not write or draw a lot. In contrast, the Stanford team had a SMARTBoard device for one session and used it to make sketches and drawings, which show the large potential of using a well-fitting hardware (see Fig. 7, *right*).

3.2 Logic Grid Puzzle

Tele-Board can be used for synchronous as well as asynchronous work. The asynchronous aspect comes in two flavors: supporting designers to work in a team over different time zones, but secondly giving researchers a tool to analyze design teams by carrying out statistical analyses on the communication data. To point out the potential of those automatic analyses, we conducted a series of tests involving ten teams of two participants each. They used SMARTBoard devices in a synchronous setting with two locations – one user at each location. We were not so much focused on the results of the teams, but more on the process of analyzing the work of the participants and revealing the differences between the teams.

To make results more comparable, the task itself was quite structured and not as creative and design-focused as in other tests. We asked the participants to work on a logic grid puzzle solving a detective story, finding out who broke in at which house etc. As a starting point, a grid with the different attributes of each crime scene was already given, as well as a set of ten hints making it possible to fill out

Fig. 7 Whiteboard content of the global students project ME310

the grid bit by bit. People were asked to collaborate on the solution, which means they often discussed certain steps of their solution process by referencing different cells of the grid, sorting the hints, and coordinating the completion of the solution.

We divided the teams into two groups: Those having a video-enabled connection (see Fig. 8), and those having video switched off and only relying on an audio connection. The hypotheses we wanted to address were as follows:

1. With a video-enabled connection, people are more efficient, i.e. solve the task faster.
2. With a video-enabled connection, people enjoy the task more, establish more common ground, more team spirit, and work together more closely.

We applied different analysis methods afterwards. Each of them has different possibilities and limitations (see Table 2). Our goal with the automatic analysis is not to replace traditional methods, but to enrich and save time on existing approaches by doing standard analysis tasks automatically.

As we expected, the task completion time – the time the people needed to solve the puzzle – was significantly faster in the video condition than in the audio-only condition (Hypothesis 1). This result could be seen in the automatic analysis using the automatically recorded data. Hypothesis 2 could not be answered as clearly. There were some tendencies showing the video condition to be more enjoyable and that people could express themselves a bit better, but those values were not statistically significant. The data was taken from a questionnaire handed out after the experiment. Detailed results are shown in Gericke et al. (2011).

Fig. 8 Remote study participants in the video condition. Deictic gestures are easily visible for the remote partner

Table 2 Analysis methodologies for the evaluation of design activity (n.y.i. = not yet implemented)

Measure	Manual, questionnaire	Video coding	Automatic analysis
Social measures, emotions	Yes	Partly	No
Whiteboard activity	No	Partly	Yes
Referencing, gestures	No	Yes	n.y.i.
Verbal interaction	No	Yes	n.y.i.
Performance, time-consumption	Yes	Yes	Yes

With this setup, we achieved our goal of showing how using an infrastructure such as the Tele-Board history can ease design team analysis. Capturing and archiving every single event of the communication process can enable many types of analyses conducted instantly without any time-consuming video coding of all experiments. We showed that Tele-Board not only allows asynchronous interaction based on the history of the communication, but also analyses of the design team behavior.

3.3 Connecting Experts on a Sustainability Conference: The B.A.U.M e.V. Jahrestagung

It is Tele-Board's goal to improve collaboration and communication for teams working at different locations without making them travel long distances. Of course, one reason is the cost aspect, but nowadays it is equally as important to avoid traveling due to ecological reasons. Especially when teams have to take long flights to the other location, the "green consciousness" of a company gets into trouble. But not only the CO_2 emissions are problematic; it is also stressful to travel on a long-haul flight including time shifts interfering with the traveler's biorhythm.

As Tele-Board addresses these issues in the broader scope of sustainability, we were invited to present the possibilities of remote collaboration and communication at the annual meeting of the "Federal German working group for eco-friendly

Fig. 9 Results of the "networking table" with Tele-Board between the B.A.U.M. e.V. annual conference in Hamburg and experts in Potsdam, Germany

management" – the *B.A.U.M e.V. Jahrestagung 2011* in Hamburg, Germany. The attendees meet in order to exchange new ideas and develop future concepts together. Applying the idea of "Netzwerktische", i.e. networking tables, groups of about ten people meet at a round table. At each table there is a moderator and an expert for the topic that will be discussed at the table.[4]

At the "Tele-Board table" the expert was located in Potsdam and was supposed to give input from this remote location. In Hamburg, we noted the most important findings from the discussion, sorting and clustering were carried out at the Potsdam location. In addition to the keyboard written notes from the web portal, the participants could scribble and draw their ideas on iPads and send them to the board. Once in a while, the expert summed up the current state of the discussion and the clustering at the whiteboard. When he was doing this, the participants in Hamburg could see his gestures with regard to the content on the board.

At the end of the "network table rounds," all groups had to present the results of their discussion in a 2 min pitch at a podium. At the other tables, the organizers took pictures of the paper notes walls and presented them. The work at our table was presented with whiteboard screenshots downloaded from the Tele-Board web portal as well as pictures showing the work in front of the board (see Fig. 9).

In general, we were enthusiastic about how well the distribution of tasks for this discussion round worked out. It was helpful to have an expert in Potsdam grouping the ideas while we could focus on the discussion. Although the main discussion took place in Hamburg, the person in Potsdam could add his understanding of the discussion by clustering the content. For the participants, it was interesting to see how the sticky notes were moved around and how the different fields of the topic were outlined. In the end, we had a well-structured whiteboard that could be

[4] For more information see: http://forum-e3.org/de/enact_2020/idee/ (in German).

presented to the audience. A lesson we learned for a future remote discussion is to improve the audio connection. At this time we had only used one microphone inside the webcam for the whole group in Hamburg. Therefore, it was sometimes necessary to repeat what was said for the Potsdam side. Having a better external microphone or even several for a larger group would ease the understanding between remote partners.

3.4 Network Performance

In contrast to the other presented tests and evaluations, we also did a review of our system from a particularly technical perspective which we presented in Gericke and Meinel (2011). We wanted to show, how the number of users simultaneously connected to the system influences the system's performance. Therefore, we created two setups:

1. Many clients in one synchronized session with variation in the number of clients connected to this session.
2. A fixed number of clients connected to each session with variation in the number of sessions.

To make results reproducible and limit statistical spread within the data, we used a command line client controlling the whiteboard client, which changes a set of simultaneously connected whiteboards periodically and thereby produces a certain amount of activity on the server side. The measurement data revealed that performance characteristics are very different between those setups. Whereas in the first condition load rises exponentially to the number of connected clients, because every client syncs each change to every other client, it is a linear growth in the second setup. Detailed results can be found in Gericke and Meinel (2011).

Looking at the current working mode with the Tele-Board system, teams usually consist of two locations, rarely more. This is because the number of connected whiteboard clients turns out to be more realistic in setup two, so that we can assume our system to scale well in a real-world scenario. The limiting factor on a server is more likely to be the network bandwidth than the computing power. Our numbers also show that the continuous storage of the communication data – enabling asynchronous operation – only has a small influence on system performance. The particularly novelty of our system combining synchronous and asynchronous working modes into one system was shown to be technically feasible.

4 Tele-Board in Use: One Location Setups

In general, Tele-Board is intended to be used in remote location setups. However, in order to improve the usability and workflow of the system, we wanted to gain some insights through single location usage, as well. In the following, we give an

overview of two studies showing the use of Tele-Board by students from the School of Design Thinking in Potsdam.

4.1 Physical Versus Virtual Boards: A User Study on Navigation Between Panels

Most of the interactive whiteboard hardware that is available on the market has a resolution of 1,280 × 960 pixels maximum. Compared to traditional whiteboard, this is not a lot of space and people will use several panels, sometimes even simultaneously. Certainly it would be nice to have multiple digital whiteboard devices, but with regard to space and costs it is also possible to switch between two panels on one board. Therefore, we conducted a study evaluating the differences of two displays over one display running two panels.

In this study, the participants were asked to cluster 49 sticky notes into meaningful groups, in order to deduce the most important insights. In one condition, two touch board displays were set up next to each other. One was filled with the sticky notes, and the other was blank. In the other condition, two panels were accessible on a single touch board, one showing the initial sticky notes and the other blank. To switch between them, users tapped a button on the bottom left of the display, which contained a miniature snapshot of the other panel's content.

Results show that working under the restrictions of a single display required slightly more time, yet workflows could continue. Users accepted the visual restriction as a condition of working with a digital system. Team members were also compelled to work more closely together, which both helped and hurt collaboration (for more information see LoBue et al. (2011)).

4.2 As Intuitive as Pen and Paper?: A School of Design Thinking One-Day-Challenge with Tele-Board

Pen and paper is easy to use – for everyone. No matter which professional or cultural background people have, they know how to write an idea on a sticky note. This is one of the reasons why in Design Thinking sticky notes play such an important role. But not only sticky notes are easy to use, working with whiteboards, and also prototyping with material – most people know from kindergarten – is not a great challenge to be learned. With digital tools it is more difficult. Though some people – especially younger ones – love to get to know new devices and tools, for others, it is a burden to have to learn new functionalities and systems.

For this reason, we were eager to know whether and how users were able to work with Tele-Board. Would they manage to do a complete design challenge with our system, only with a small introduction to its functionality? Would they need more

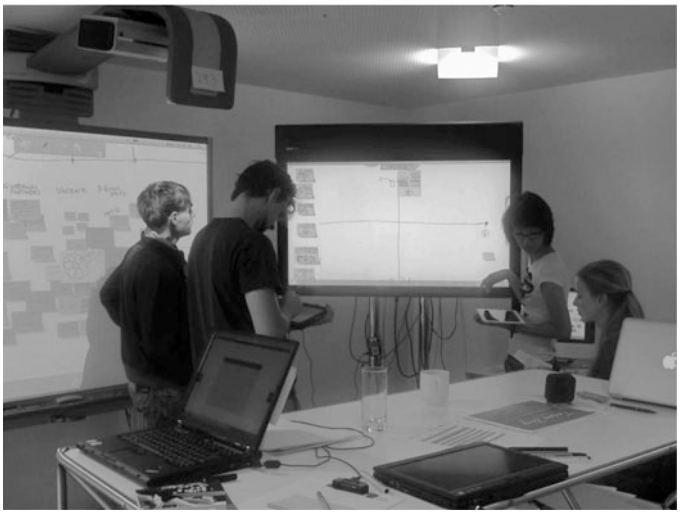

Fig. 10 Setup of the One-Day-Challenge with Tele-Board. At the table and in the hands of the participants are the different tools to write sticky notes

time, compared to working with paper notes and traditional whiteboards? On the other hand, would there be advantages of Tele-Board to help teams to work more efficiently than they are used to?

Therefore, we gave five teams of four people each a design problem and let them work with Tele-Board on a One-Day-Challenge. As we were interested in a comparison with the analog world, we had one additional control team that was working without Tele-Board. All participants had experience with Design Thinking using traditional whiteboards and tools.

In the beginning, we explained all functions of the Tele-Board whiteboard client to the teams and showed them how to write sticky notes with the different devices: We provided four iPads with the *Sticky Pad HD* App (including special iPad pens), a TabletPC, a digital pen (connected to a laptop) and a laptop for writing sticky notes via the Tele-Board web portal (see Fig. 10). The participants were also given a limited amount of time to try out all functions and to get used to the system.

As a main result regarding the time, we found that all teams could accomplish the task and came to satisfying results during the given time frame. We could not see any difference in the timing of the different phases between the control team working without Tele-Board, and the other teams. We could observe that the ease of use and comfort with the system was related to general openness and curiosity towards new technologies and digital tools. That is to say, participants who tried out all Tele-Board functions enthusiastically in the beginning also learned the functions much faster.

Comparing Tele-Board and the traditional tools, we observed that, in general, the teams' usual way of working did not have to be changed and the teamwork was similarly fine. For some people, there was hardly any noticeable difference between traditional tools and the digital system. They even claimed it to be timesaving

compared to the analog ones. On the other hand, some participants had difficulties getting used to the system and said it would slow down their work. This was mainly observable with people who were rather shy with trying out all functions. When they could not find what they were looking for in the first place or the system did something they did not expect, they were afraid to try out other things afterwards. Still, with all participants we saw a fast learning effect during the course of the testing. We also observed that it was a great advantage when two of four team members walked through the system easily, because they then showed the others what they found out and after a short while the whole team had no difficulties anymore. In teams where all participants were rather cautious, it took them a longer time to get used to the Tele-Board system.

Besides observing how Tele-Board was used by the teams, we learned which functions were easy to use and which were a bit cumbersome. Thereby, we could also improve the usability of the whiteboard client and add the new functions the teams had suggested. The general feedback of all teams was that they could definitely imagine using Tele-Board for other Design Thinking activities, especially when they have to work in globally distributed teams.

5 Outlook and Future Work

In this chapter we have introduced the Tele-Board system that supports collaborative work in synchronous as well as asynchronous and remote as well as co-located settings (Gumienny et al. 2011). Besides enabling the collective work on the same content at the same time, the automatic storage of whiteboard interaction offers a second-by-second history view (Gericke et al. 2010). The history view enables users to reproduce the progress of a (design) project process. This is very important especially for teams that cannot work on a whiteboard at the same time. Team members can comprehend easier which decisions their colleagues made, earlier in a different time zone.

Recently, we had the opportunity to test Tele-Board in several real world scenarios. In the course of these tests, we were able to monitor user interaction with the system in co-located as well as in remote settings. Our user's general impression of Tele-board was overall positive. Nevertheless, we got valuable feedback that helped us to improve our system. Furthermore, it turned out that for traceability of the design session progress it would be very helpful to recognize the most important phases and present them in the history browser. A prerequisite for suggesting important points of a design session history is an analysis of the stored history data and identifying situations with high information value. Such moments can be, for example, when a team came to certain decisions or had seminal ideas. During the past project year, we collected several hours of test data, which will be the basis for our future research. The obvious commonalities in these processes can be transferred to computational analyses.

5.1 Evaluating Our Ideas and Designs

In the future, we can make use of Tele-Board's advancements of the last years and deploy the system in industry contexts. This way we can conduct long-term research in real working environments on the use of digital whiteboard systems that has not been possible before. We can find out which functions and properties of the system foster and which ones hinder remote collaboration. As Tele-Board can be used with a variety of different hardware, we can easily change settings and try out different setups. Through former tests and experiences we know that we have a good basis for a successful launch of the system and can then adjust it for an optimal experience of the users. Additionally, we will further develop and evaluate special functions for synchronous and asynchronous work. We can demonstrate the possibilities of an all-digital solution such as the Tele-Board system and evaluate the impact for team interaction, their performance and Design Thinking in general.

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