

# EXAMINING CREATIVE COLLABORATION IN DISTRIBUTED AND CO-LOCATED DESIGN TEAMS

Mattias Bergström, Peter Törlind

Faste Laboratory, Division of Functional Product Development  
Luleå University of Technology, Sweden

## ABSTRACT

Product development, including all its phases, is today performed to a greater extent in globally dispersed teams. This paper compares two creative design sessions early in the product development process, one co-located session and one distributed session. The workflow in the co-located session was fluid and natural, whereas in the distributed session, it was sometimes disturbed by limitations of the mediating technology. The major deficiencies of the technology are the limited support for shared drawing surfaces, for shared control of these surfaces and for creation of concepts. In the co-located session embodied representation were used to describe, communicate and build upon concepts. Due to the limitations of the technology, these types of communication were seldom used in the distributed session.

*Keywords: Distributed Collaborative Engineering, Global Product Development, Virtual Teams, Design Studies, Team Creativity*

## 1 INTRODUCTION

Product development is no longer performed in just a single company, but rather in cross-company and cross-disciplinary teams. Different companies that are not geographically co-located build up the extended enterprises and an even greater need to work in a distributed fashion is thus needed. Early phases of product development are a socially oriented and creative activity [1]. A multi-disciplinary setting nurtures creativity [2, 3], and raises challenges for collaborative team members to develop a shared understanding for the product at hand. This is also true in a distributed team where diversity is even larger (different cultures, background and language). Besides not being in the same location, the supportive technologies that facilitate distributed work might also cause disturbances in the creative and social processes for the design team; co-located team communication is often more natural and fluid than in a distributed meeting. Although working in distributed multidisciplinary teams involves immense challenges, there are also significant opportunities that come with geographical distribution [4]. Diversity in a distributed team can improve the outcome if they can manage to work together. Törlind et al. denotes *true collaboration* as: “*where diversity and competences of the whole team can be utilized and where team members can think together rather than merely exchange information, opinions and divide work*” [5, p11].

During a creative design process a vast range of tangible media is used. In the early stages, concept models and sketches are essential to create a shared understanding in the design team [6]. A deeper insight into how tangible media is used in the process provides valuable input to the development of new technologies that support distributed collaborative engineering. Thus, based on a qualitative approach, the focus of this paper is to compare how virtual design teams collaborate in creative phases, both in distributed and co-located creative sessions. The purpose is to provide input to the further the development of supportive technology for distributed collaborative work.

## 2 ARTEFACTS IN DESIGN COMMUNICATION

Product development of hardware always renders hardware, an artefact. Since the goal of a product development process is to develop the artefact it is fairly obvious and inevitable that representations of that artefact will be of great importance throughout the process especially for communicative purposes. It is suggested that there is two types of artefacts in design [6]. Firstly, there are *design*

*artefacts*; sketches, models, prototypes, etc. Secondly, there are *procedural artefacts* such as; office memos, letters, Gantt charts, etc. “*Design artefacts represent a thought about design, whereas procedural artefacts convey the anticipated design process and help to orient people to it*” [6, p275]. Perry and Sanderson conclude, “*Computer technologies designed to facilitate the design process have so far not attempted to link design artefacts to their role in communication and coordination.*” [6, p287]. The process of interacting with objects has communicative value and alters the dynamics in collaborative work [7]. Bucciarelli states, “*Objects are continually at hand as a focus of thoughts or a topic of discourse*” [8, p25]. Wagner [9] writes that images can help a designer talk about design in a rich and metamorphic manner and can be pointed and referred to. Visual and graphical material can also act as reminders of design principles, approach, method, open questions, etc. Wagner concludes that visual and graphical material helps to create a common understanding of the design idea.

In *Making Sense of Collaboration* [10, p.159], Larsson describes that the observed group used gestures, sketches, prototypes, etc., to visualize what they wanted to ‘say’ when verbal language was not enough. Further, he concludes, “*While shared electronic media is useful and many times sufficient for distributed design, the addition of shared ‘objects to think with’ is an interesting approach to the further advancement of global design collaboration.*”. Brandt [11] uses the term “*things-to-think with*”, she finds that tangible mock-ups may be used to span the gap between different competences in and interests of participants and thereby acts as a support for the design collaboration.

Design teams are heavily reliant on physical references such as tangible artefacts to help them think through design problems. Quick rough prototypes are often preferred to those more time consuming. Brereton and MacGarry [12, p.217] explore how engineers use physical objects to prototype design and conclude, “*Design thinking is heavily dependent upon references to physical objects and gesturing with physical objects. Designers are active and opportunistic in seeking out physical props to help them think through design problems and communicate design ideas.*” Aside from inert artefacts, objects or prototypes, the body of a designer can itself also be used as a means to communicate ideas. Harrison and Minneman find *embodied representations* [7], i.e. the use of the body to animate and visualize ideas, interesting as a future study. Kelley uses the term *bodystorming* [2 p.63], referring to brainstorming sessions where designers use their entire body as a mean to act out a scenario thus learning more about the scenario as they often act as the user. This gives the designers an alternative view on the scenario that will help them in the creation of new concepts.

## **2.1 Distributed design**

Existing collaborative tools poorly support these highly collaborative creative sessions, such as brainstorming in distributed teams, by only using a shared whiteboard where several modalities are lost, e.g. body language, gestures, gazes, eye contact and side conversation. Several research prototypes have, however, made an effort to overcome this limitation. Everitt et al. [13] presented the *Distributed Designers’ Outpost*, a system that combines physical post-it notes with virtual objects and where remote collaborators are visible as shadows that provide a sense of presence between the collaborators. Tang and Minneman [14] presented VideoDraw, where users used whiteboard markers to sketch on a display, and a video camera to capture the sketches and the gestures displayed on the remote display called VideoWhiteboard [15], which also added the ‘shadows’ of remote users. The *ClearBoard-2* system [16] is similar to VideoDraw and adds a superimposed view of the remote participant in the display so that both gestures and gazes can be viewed. Törlind [17] presented another approach with normal whiteboards where the video could be augmented with virtual annotations (pointers, text, etc.) overlaying the video.

## **3 METHOD**

The empirical base is found within the distributed team innovation approach [4], a collaborative effort between the SIRIUS course at Luleå University of Technology (LTU), Sweden and the me310 course at Stanford University, USA. During 2005/2006, the researchers followed 2 global projects each consisting of 4 students from Stanford and 4 from LTU, totalling 16 students. The projects were conducted in close collaboration with corporate partners, the user needs were identified in real life settings and the students owned the process themselves. The researchers followed one of the projects. Based on a qualitative approach, two design sessions are compared, the *co-located creative session* and the *distributed creative session*. The global design team was studied over seven months.

The study performed was inspired by ethnographic methods [18] and besides being present during the design session performed by the students, both co-located and distributed collaborative activities were videotaped. Field notes and the course of events from the videos were transcribed and analysed. The distributed sessions were followed and videotaped from the Swedish site in Luleå. For this paper, two design settings are compared and discussed, a *co-located creative session* and a *distributed creative session*. Data from the co-located creative session was generated when the Stanford students visited the Luleå students, which was the first time the students had gathered at the same site, after the project had run for two months. The distributed creative session was performed one month later.

#### 4 THE CONTEXT FOR CREATIVE SESSIONS

The co-located creative session occurred when the Stanford students came to visit those at LTU for the first time and meeting face-to-face, viz. a co-located design session. The distributed session was an attempt at the same kind of creative session as the students did in the face-to-face setting, though in a distributed fashion.

##### 4.1 The co-located creative session setup

For the co-located creative session the students gathered at the Luleå students' team space, i.e. a room the students occupy during the course. The room has a basic setup consisting of a table in the centre of the room, a white board on one wall, pin board on the other wall and a desk with a computer fitted for videoconferencing. The team set up the room for a creative session instead of using their own personal writing surfaces, e.g. sheets of paper, they decided to use just one big sheet of paper covering the entire table, a *shared surface*, as seen in Figure 2. The topic of the session was written in the middle of the paper.



Figure 1. The Co-located creative session, the team is sitting around the paper spread out on the table.

##### 4.2 The distributed creative session setup

For the distributed design session the students made sure that everyone attending the meeting understood the goal of the meeting, i.e. to generate many ideas for the project. The Luleå students decided not to use their team space and the accompanying computer for the distributed creative session, but instead gather in the STUDIO. The students were not prompted to use the existing facilities or technology in any way; the setup and how the technology is used were their own decision. The STUDIO used a big back projection surface as the primary display surface for videoconferencing. The Luleå students used the floor in the STUDIO for them to work, spreading out a big sheet of paper

on the floor as they did in the co-located setting. The paper was spread out on the floor in front of the back projected screen, as seen in Figure 2. The students used one pan/tilt/zoom video camera that they controlled with a remote and arranged it to initially point at the paper showing concepts that the Luleå students were working on.

The Stanford students gathered in their team space, which was equipped with a 30” widescreen LCD, a computer used for videoconferencing and a tabletop microphone with built in echo cancelling unit. A portable whiteboard was used as their primary sketching surface.

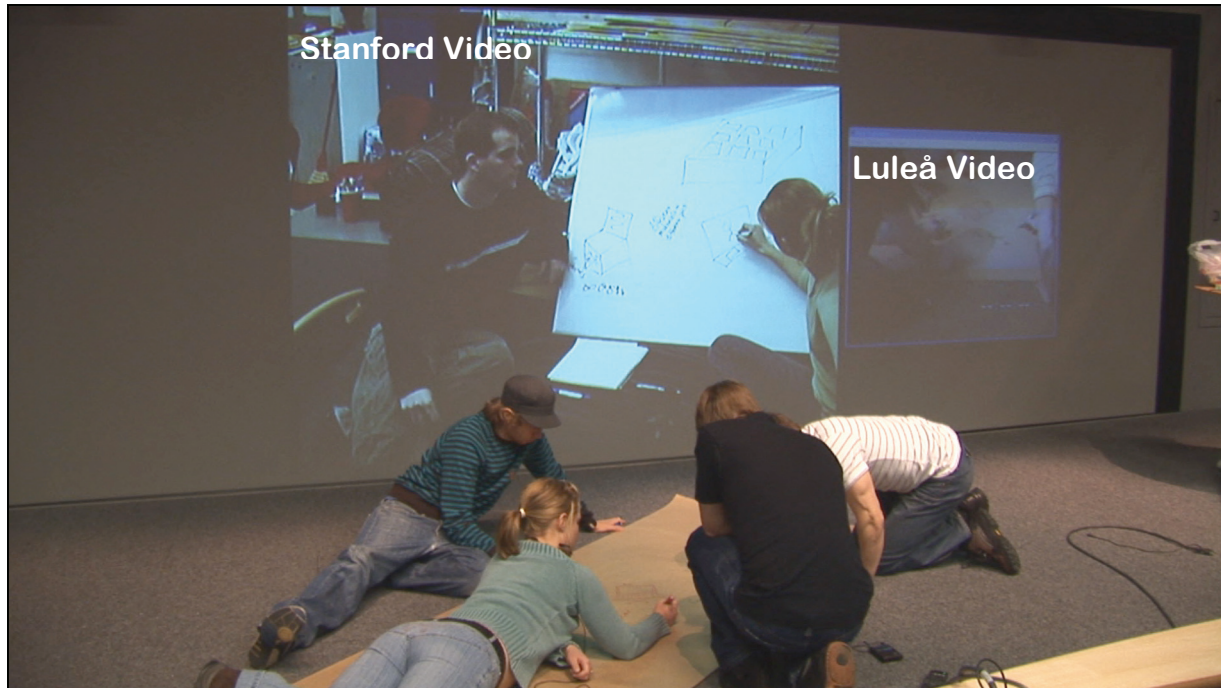


Figure 2. The distributed creative session, the team is sitting around the paper.

## 5 CREATIVE COLLABORATION IN THE STUDENT TEAM

The creative sessions are presented in three two-folded scenarios that describe distributed and co-located activities. Scenario 1 describes distributed and co-located communication when sharing spaces and surfaces, scenario 2 describes distributed and co-located activities when using body language to support communication and scenario 3 describes distributed and co-located activities when voting on concepts.

The co-located creative session is described as played out with statements from the participants in *italic*. The distributed creative session is outlined in the same way. Each scenario is then summarised with a comparison and a discussion of the occurred events.

When referring to all eight students as a group, the term ‘team’ will be used. Luleå Students (LS) will be used for students from Luleå University of Technology and Stanford Students (SS) for students from Stanford University. However, to specify students in this study, students from Luleå will be named with an L followed by the initial of their first name subsequently, while Stanford students are named with a S followed by their first initial. The Luleå Students are LA, LG, LM and LP, the Stanford students are SA, SB, SH and SJ.

### 5.1 Scenario 1: Sharing space and sharing surface

#### 5.1.1 Description of co-located creativity session – scenario 1

In the co-located setting the students used one big sheet of paper spread out on a table as a communal paper. At the beginning of the session the students sat at their own space and drew their own concepts. When they felt that they had exhausted their storage of ideas, they looked at what the others had come up with. The goal at this stage was to build on the ideas of others, or as the facilitator SJ stated, “stealing the ideas of others is allowed... or actually stealing encouraged”. As the students walked around the table, they interacted with each other and began small discussions, where one student

would describe his or her ideas to the others; they often used the concepts already drawn on the paper as a reference to fuel their discussion, Figure 3. Sometimes the discussion would become the main discussion, whereas at other times there would be multiple discussions going on simultaneously. The discussions usually added to the existing concept or added an entirely new concept to the paper.



Figure 3. The team are discussing and building on the concepts drawn on the paper.

### 5.1.2 Description of distributed creativity session – scenario 1

LM in Luleå wants to point to the whiteboard at Stanford, and asks LP to rearrange the camera perspective to point to the screen instead of pointing to the paper spread out on the floor. As the camera pans to the screen, SA sees herself and says, "You can see my head and it is really big..." and ducks out of the picture.

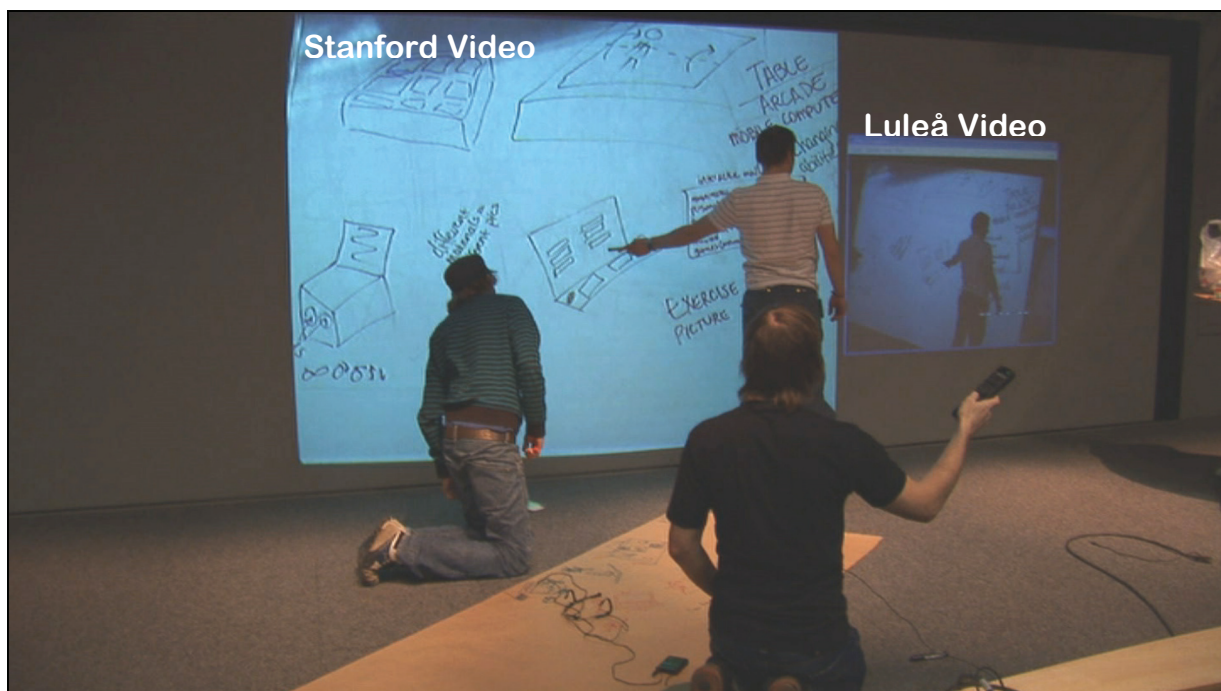


Figure 4. ML is calling attention to objects on the whiteboard, which is physically located

at Stanford.

LM, who has been sitting on the floor, jumps up, points to an idea and asks, "... so, so what was this idea?". As SA explains the idea the Luleå students stand up. SA continues pointing at other ideas on the whiteboard and explains how they work. SB puts up another concept that has been drawn on a sheet of paper.

LM asks again, "explain that..." and suddenly he stops. The students are silent, LM walks up to the screen and points to the new paper drawing and says, "...this one", exemplified in Figure 4.

SB begins to explain what the concept is about, while another concept on a piece of paper is put on the whiteboard. A third concept is also put on the board and explained to the group.

LG points to one of the concepts depicting a sun chair and says, "I like this one."

### **5.1.3 Comparison of co-located and distributed work – scenario 1**

In the co-located creative session, the whiteboard and the paper on the table are used as shared surfaces. The distributed session shows that it is possible to use a single physical surface, i.e. the whiteboard at Stanford, to present all concepts. The Luleå students have a perfect view of the whiteboard, but are unable to manipulate it directly and have to go through one of their Stanford colleagues to do so. Hence, they are not in control of the surface, i.e. the control is not communal. When using a whiteboard in a co-located setting anyone can take control of the surface. However, the entire Luleå team can focus attention to certain concepts or topics on the whiteboard, since they can point to it via their video.

In the distributed session, building on the concepts of others is difficult compared with the co-located setting where each team member can walk around the table and interact with the surface. If they found something interesting team members could build on it on their own or in collaboration with others. The side conversations that occur may or may not influence the main discussion. In the distributed setting, only one discussion occurs at a time and it is difficult to have a side conversations.

One main difference between communication patterns in distributed and co-located sessions is that in the latter multiple discussions seem natural. Side conversations started as soon as the students began walking around. The side conversations sometimes contributed to the main discussion. In the distributed session there was one discussion going on, with only local side conversations. This might be because a side conversation, when using videoconferencing technology, disturbs the main conversation more than it contributes.

## **5.2 Scenario 2: Interacting with body language**

### **5.2.1 Description of co-located session – scenario 2**

There is a discussion about a concept concerning auto tooth brushing. With his hands, BS is showing how a robot might automatically brush teeth. LG enters the conversation and says, "Auto tooth brushing... it can be quite hard to brush your teeth." LG shows the motion you perform when brushing your teeth. There is a pause, and then SB says, "You just stick your face out." And he leans forward with his head while showing with his hands how something comes up and enters the mouth. SH is sitting with his mouth open. LG joins SB and says, "you just..." , opens his mouth wide, leans his head forward and shows with both hands how an automatic brushing robot might work, Figure 5. Everybody around the table laughs.



Figure 5. LG is showing the concept of an automated toothbrush.

### 5.2.2 Description of distributed session – scenario 2

LG is explaining one concept, while looking directly at SA on the screen. He is facing her, as in a co-located meeting, looking at her addressing her. As LG explains his concept to SA, he mimics the concept of driving a car, and then realizes that she cannot see him because the camera is focused on the paper and not on him, left Figure 7. He then reposition himself, brings both of his hands down to where the camera is currently focused and explains the concept again, but this time he makes sure that his hands are visible to SA, right Figure 7.

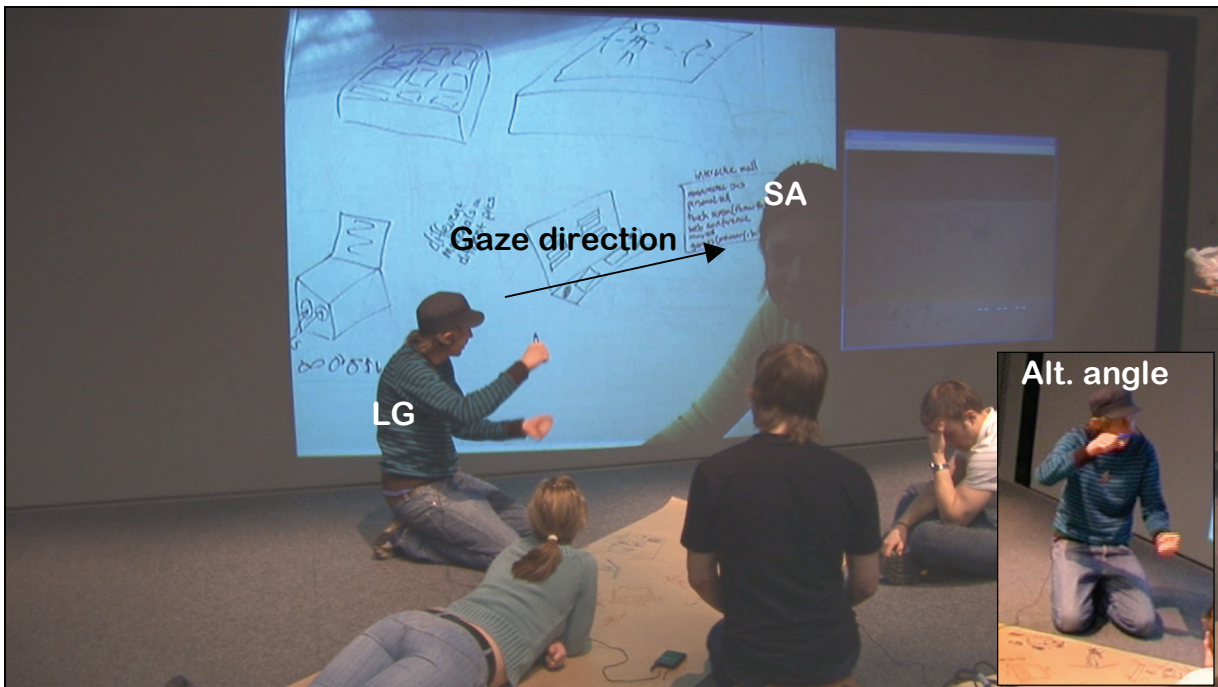


Figure 6. LG uses his arms to visualize driving a car, he then realizes that SA cannot see him and changes his position, bottom figure.

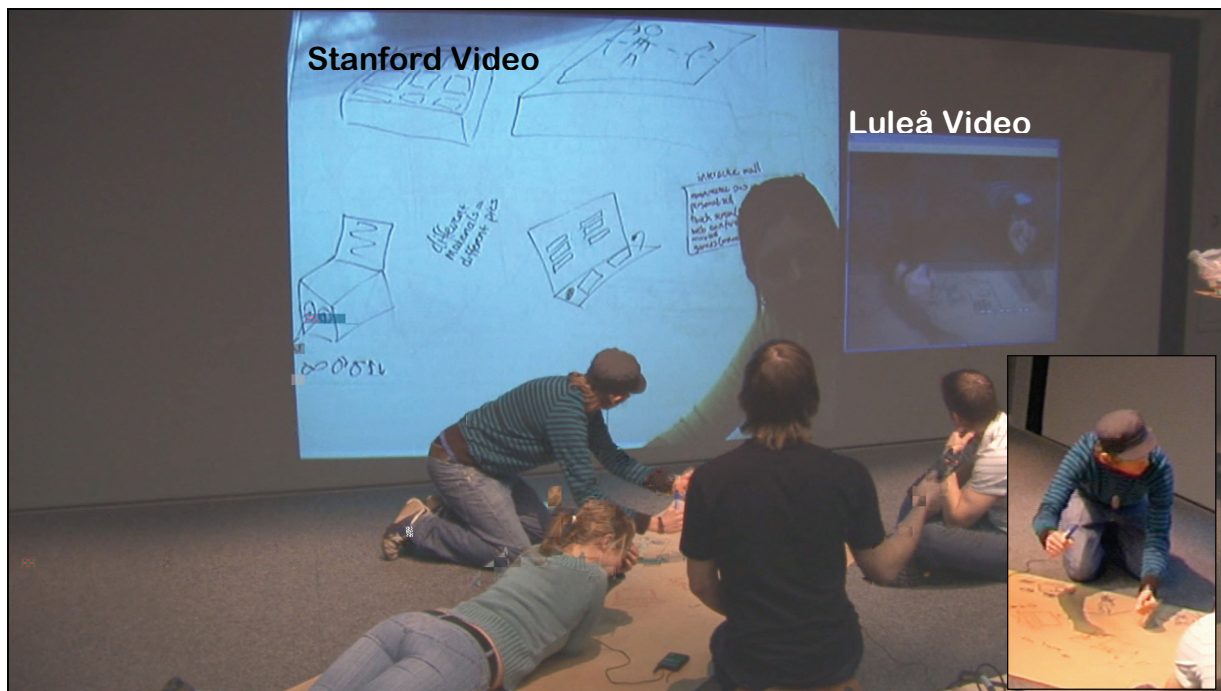


Figure 7. Top figure: LG uses his arms to visualize driving a car, he then realizes that SA cannot see him and changes his position, bottom figure.

### 5.2.3 Comparison of co-located and distributed work – scenario 2

Where would one ideally place a camera in distributed scenario such as the one described above? The camera position is different compared to a ‘normal’ videoconferencing session, where the camera would point towards the local group, though in this session the team placed the camera to face the floor and the screen. Despite being aware of where the camera is they do not face the camera to communicate, but rather face their local colleagues or the distributed colleagues on the screen to gain eye contact. The communication cannot flow seamlessly if the meeting participants have to be concerned with being on video.

The students use their bodies to communicate, embodied representations [7]. In the distributed creative session LG used his hands to show how you drive a car, Figure 7, and the distributed partners understood what he communicated. The workflow in the co-located setting was that the students were building upon each other’s embodied representations. SB began showing with his hands, then LG copied him and adds a motion. SB then stuck his face out as to show that this could be automated. LG tops it all off by combining all motions, thus showing the entire concept, Figure 5. Meanwhile, SH is sitting with his mouth open as if he is imagining how it would be to experience an automated toothbrush.

## 5.3 Scenario 3: Personal or group concepts and voting for concepts

To narrow down ideas and retain those that appeal to the team members, the group can simply vote on the concepts; Kelley [19], for instance, describes this quick and dirty concept screening method. Each team member has two to four votes, depending on what is decided. This way the group will only be left with the best ideas from the brainstorming session. Team members typically vote on concepts by leaving a mark, such as a dot or a post-it. The concepts receiving more than one vote move on to a more extensive evaluation.

### 5.3.1 Description of co-located creativity session – scenario 3

In the co-located meetings each team member described their concept to the other members, while AS wrote down each concept on the whiteboard. When all concepts were listed on the whiteboard, the team members gathered around the whiteboard to vote for their favourite concepts, Figure 8.



### 5.3.2 Description of distributed creativity session – scenario 3

All the concepts are represented on the whiteboard at Stanford; the Luleå students' concepts were explained by the Luleå Students, as described in scenario 2. SA wrote down each concept with a name, e.g. 'Table' or 'Arcade', The concepts from the Stanford students are either drawn on paper placed on the whiteboard or drawn directly on the whiteboard.

The group decide that they should proceed to narrow down the concepts when SB says, "I don't know, maybe we should vote or something... on your favourite". LG replies, "Yes, I think that... that's good." SH says, "Lets put dots... next to everything... everybody gets two votes." The Stanford students vote quite fast, SB and SA put down their votes without any comments as they stand on either side of the Stanford whiteboard, the other two simply tell SB how they wish to distribute their votes in rapid succession, Figure 8. As the Luleå team is just about to vote, LA says, "We can use that thing..." pointing towards the wacom board. She continues, "...to put dots ourselves." LG replies, "Do you want us to put dots on the screen?", as he uses a marker to point to the screen. LA replies, "haha... funny guy". The session continues and the first of the Luleå students to vote is ML, "I vote the same as you, BS." The second one to vote is LG, "My name is LG... I vote for the Table and... " LM whispers to him "your table", and then LG says, "Yes... I vote for my Table, G Table." After some time LP decides how to vote, but LA needs more time and more information about the concepts to decide where she to cast her votes. LA puts her first vote on the 'Table'. LM repeats yet again that this concept is "The G Table", SB says "the G Table". "That's right B", replies LG.



Figure 8. Distributed voting, left figure. Co-located voting, right figure.

### 5.3.3 Comparison of co-located and distributed work – scenario 3

It is more difficult in distributed sessions to create group concepts. When voting for or evaluating concepts it is preferred that concepts do not belong to anyone in particular, but the group as a whole. The creation of group concepts is important to prevent a bias towards certain concepts, which is important in the evaluation of concepts; another way is to use matrices such as Pugh's evaluation matrix [20]. The media in which concepts are presented shows by default that concepts are from either one side or the other.

In the distributed session LA came up with the idea to use the wacom display<sup>1</sup> available in the STUDIO to vote for themselves, but the others had not understood what she proposed and decided to discard the idea. She wanted to use it to place dots on the Stanford whiteboard, providing the Luleå students greater control. The Stanford students had the whiteboard in their team room, and were thus in total control of the interaction with contents on the whiteboard. For the Luleå students to manipulate the whiteboard content they would have to ask one of their colleagues at Stanford to manipulate it for them. As in described in scenario 1, the Luleå students' only interaction with the whiteboard was being able to point to areas on the whiteboard.

Ideally, the students could vote for concepts themselves rather than publicly. The process of voting for concepts in itself is usually closed, such as in the co-located session when the students voted by themselves, but the end result was public. When voting for concepts you can simply place dots/post-

<sup>1</sup> A Wacom display is an integration of a digitiser and a display, <http://www.wacom.com>

its/markers/etc. next to concepts you wish to vote for. The other way to vote is to put plus and minuses with design rationale on each vote, e.g. ‘+ this concept solves the need of availability, - better glue is needed to make it feasible’. When the process of voting is open there is a risk that group pressure influences the voting process, especially if a design rationale is to be given when the vote is put in.

## **6 DISCUSSION**

It is clear from the comparison of the co-located and distributed creative sessions that the technology that enables the team to interact in a remote session also has several limitations that hamper communication and collaboration.

### **6.1 Creating a sense of connectedness**

The use of large projection surfaces to display distributed partners helped the students to create a sense of being together in the same room. The students sat in an arc on the floor of the STUDIO facing the projection surface and formed a virtual ring together with the Stanford students. The Luleå students faced the projection screen and the camera faced the paper that was spread out in front of the screen. If the paper would be extended to the projection surface, the paper and the whiteboard would create a sense of being one surface.

The students sometimes acted as though they were sitting in a real circle, not in a distributed meeting. In Scenario 1, one student faced the screen to get the attention of the distributed partners when explaining the concept. Although he did not face the camera, he was aware of the camera position and quickly corrected his position to be visible on camera, while continuing to face the projection surface at all times.

Camera position is a concern in distributed synchronous collaboration especially in creative sessions, where the participants tend to move around the room. If cameras are placed without care they might not capture certain events or the participants must change position to be visible to their distributed colleagues and thereby prevent a natural workflow.

### **6.2 Shared surfaces and side conversations**

The setup and the use of an standard whiteboard at Stanford deprived some control from the Luleå students; after the presentation of their concepts, the concepts were presented only as a name on the Stanford whiteboard. The Stanford concepts were either drawn directly on the whiteboard or on separate sheets of paper, which were posted on the whiteboard. The difference in representation of the concepts on the whiteboard and the fact that the Luleå students had less control over the content on the whiteboard resulted in greater difficulty to build upon the concepts of others in the distributed session compared to the co-located session. Another reason why there was a lesser tendency to build on the concepts of others might be that in the distributed session side conversations are not supported, meaning that there is only one main conversation between the sites and local side conversations, rendering the session less dynamic than a co-located session. The side conversations on either side were also purposely directed so that the other side could not contribute. One example was when LG explained concepts in Swedish. Since the Stanford students did not have a chance to understand, they had no chance to comment or contribute and were thus completely shut out of that particular discussion. When discussing concepts a shared understanding is built and because the Stanford students were not part of the discussion they did not participate in this shared understanding.

### **6.3 Body language**

The communication flow is hampered in the distributed creativity session compared to the co-located creativity session. In the distributed session a student explained his concept by embodied representations. In the co-located session the students performed the same type of concept embodiment. As a student embodied a concept, others built upon the concept by adding new motions that further improved the embodied concept. The students mimicked other users for improved understanding of the concepts. This shows that embodied representations are an important part of design thinking. Designers are prone to touch, feel and embody artefacts to understand them and to understand each other. In a co-located session, this type of embodiment of concepts flows naturally in a way that is still not present or supported in a distributed setting, the technology for distributed meetings does not support the modalities and the flexibility needed.

## 7 CONCLUSIONS

This study is descriptive and compares the differences of two creative sessions early in the product development process, one co-located and one distributed. Some shortcomings of the mediating technology have been illuminated in this article, the main differences are found in Table 1.

Table 1. The difference in communication in the co-located creativity session and the distributed creative session.

	Co-located creative session	Distributed creative session
Awareness of physical environment	Natural awareness of physical environment.	Low awareness of remote view of local physical environment
Body language	Embodied representations and Bodystorming	Embodied representations
Side conversations	Rapid transitions in and out of the main discussion, several side conversations co-exist.	Only local side conversations exist, side conversations may also disturb or halt the main conversation.
Shared surfaces	Intuitive access to common shared surfaces.	Common view of shared surfaces, only local access.

Supporting a communication flow that naturally occurs when working co-located puts new challenges on future collaborative environments. The uncertainty of how the remote site views the local environment prevails fluid discussions, when the user must always adjust the camera position or move around to be visible. If the communication flow is to be more natural, such as in the co-located setting, it could also give greater support to embodied representations and potentially support the flow of a bodystorm. Another limitation of remote collaboration is the lack of side conversations that are important for the communication of ideas to all members of the design team, and can also be crucial in building on the ideas of others. In a co-located session several side conversations can co-exist, and in many cases may enrich the main conversation. Side conversations in distributed settings may disturb or halt the main conversation. Shared surfaces with common access for displaying and interacting with concepts are also crucial if the design team wants to build on the ideas of others.

## 8 FUTURE RESEARCH

For future research, the knowledge of technological shortcomings can be used to further improve existing technology or to create a new system to support distributed creative meetings. Another study that would give valuable input to further advance distributed technologies is how designers generally use artefacts in distributed work, not just in creative sessions. There is also a need for a greater understanding of how embodied representations can be supported in distributed sessions.

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Contact: M. L. Bergström  
 Division of Functional Product Development  
 Luleå University of Technology  
 SE-971 87 Luleå  
 Sweden  
 +46 920 491000  
[Mattias.Bergstrom@ltu.se](mailto:Mattias.Bergstrom@ltu.se)