

# Learning Conceptual Design: Collaborative Activities with Electronic Whiteboards

*Hillevi Sundholm, Robert Ramberg*

Dept. of Computer and Systems sciences  
Stockholm University/The Royal Institute of Technology  
Forum 100, S-164 46 Kista, Sweden  
E-mail: {hillevi, robban}@dsv.su.se

*Henrik Artman*

Dept. for Numerical Analysis and Computer Science  
The Royal Institute of Technology  
S-10044 Royal Institute of Technology, Sweden  
E-mail: artman@nada.kth.se

**ABSTRACT:** This case study reports on collaborative design of an interactive artifact. The team works in the iLounge, which is designed and built with the purpose of supporting co-located collaborative work. iLounge is equipped with several horizontal large screens, called Smart boards, where the team members can make their contributions available to all others. We have studied how the students learn to use the electronic whiteboards in order to express their ideas, how the electronic whiteboards support them when making their conceptual design, and how they express themselves when using them. The results presents how whiteboards serve as a collective memory of earlier discussions and negotiations, it also gives the users opportunities for re-negotiation and re-representation of design proposals.

**KEYWORDS:** Learning, Interaction design, Technological support, Electronic whiteboards, Co-located collaboration, Interactive Spaces

## INTRODUCTION

Design in professional practice is seldom a completely solitude activity. Designers share sketches, integrate different modules, present sketches and design proposals to costumers, and in more complex design tasks even design in collaborative teams. Collaboration is especially important in early stages when the general design concept has not been agreed upon or not been dealt with thoroughly. Most learning situations, in general and in design, in spite of this are often organized around solitary tasks and examinations. Particularly in recent years, educative practice has changed and is more focusing on collaborative and team tasks and examinations – often in smaller projects.

Our research concerns learning and design in co-located collaboration, where teams work in technology supported environments (called interactive spaces). We have studied

a group of students working on a design task in an interactive space for two weeks with the purpose of describing how this interactive space (as an example of an environment meant to support collaborative work) support this kind of work. A previous study investigated how the workspace supported the collaborative processes through which creative interactions can emerge (reported in [22]). In this paper we focus on learning to use the electronic whiteboards, and how the public screens (i. e. Smart boards) support the participants in their conceptual design process. More specifically, how the electronic whiteboards mediate discussions, argumentation, negotiation and critique.

## Collaborative Creativity

When thinking of group work and co-located collaboration, centered around the collective work of coming up with new and innovative ideas, the most common way of viewing this kind of situation is that all the group members should be gathered together in order to come up with creative solutions for the particular task at hand. But as reported in [22] it is not necessarily the case that all persons in the group have to work together in the sense of trying to share all the thoughts in the work process. Physical space matters when it concerns getting ideas into the discussions immediately, but this does not mean that a great influence cannot be made in the joint group work even if the group members work relatively physically apart. We have used the metaphor backdoor creativity to show one kind of division of work that has been part of the creativity of the group as a whole. The analysis of the study indicated that even if a group member left the group to work individually for a while, it was still possible to impact the group as a whole, and contribute to the end solution. It is interesting as it showed how even peripheral, in a physical sense, team members were contributing to the teams overall creative work.

## Learning Design Practice

In theories of cognition and learning there has been a shift in focus from the individual and what goes on in an individual mind towards appreciating the social and situated aspects of cognition and learning. This shift in focus suggests new approaches to how instruction should

In CADE2004 Web Proceedings of Computers in Art and Design Education Conference, M. Agger Eriksen., L. Malmberg, J. Nielsen (eds.). Copenhagen Business School, Denmark and Malmö University, Sweden, 29 June – 1 July 2004. [asp.cbs.dk/cade2004/proceedings/](http://asp.cbs.dk/cade2004/proceedings/)

be carried out (see for instance [1, 11, 17, 21]). Knowledge is socially constructed and central to learning is the process of gaining membership in social communities of practice [2, 11, 15]. Broader conceptions of instruction and learning thus view context and environment as crucial aspects of learning. Instruction is thus not seen as having information conveyed to the learner but participation in the activities and conversations of a community is viewed as central. This view on cognition and learning is reflected in so called socio-cultural perspectives on cognition that recently have received much attention in the literature, i.e. activity theory [5, 6, 10], and distributed cognition [7, 19].

In domains such as design and interaction design, the learning goals are often difficult (if not impossible) to define in a precise manner. In this sense, design, interaction design and learning of these domains are often ambiguous. The need to reflect, discuss and evaluate different ideas, design proposals, etc. is therefore crucial to learning and practice of design. In professional design, negotiation is a crucial part of the design situation and the student has to appropriate such knowledge to be prepared for this. Especially, in the conceptual stages of design, negotiations between different designers (system architecture, database, interaction design) are important. But also, when integrating designs it is important, particularly if the general design concept has not been agreed upon or not been dealt with thoroughly. Sketching, drawing, i.e. representing design ideas and learning to represent ideas have been found to be crucial to the design process and also to development of design ability [12]. Further, in studies of students representing scientific phenomena a meta-representational-competence has been suggested to lie behind student's abilities to create, critique and adapt a variety of different scientific representations [4]. Investigations into this phenomenon are called for and it can be hypothesized that this phenomenon is also crucial to less well-defined domains, such as interaction design. Instead of focussing individual representations, learning or talent in design processes, we both let the students learn through collaboration as well as analyzing their collaborative accomplishments.

Furthermore, the need for research into representations and learning as related to immersive technologies has been called upon in research on multimedia and learning [18], as well as in design based research [3]. This is especially the case in technology rich environments that have been developed to support collaboration in and learning of various target domains. Important to understand is how these environments are used and how people come to learn to use the tools and artefacts in the environment in, for the task, a fruitful way.

### **INTERACTIVE SPACES**

The traditional approach within human-computer interaction is to focus on the one user – one artifact situation. The workspace changes dramatically when there are many users in a space with many artifacts, and it changes even more when information can be displayed in

public as well as in private. The ideas with ubiquitous computing, pervasive computing, ambient computing, and calm technology are more or less the same. More precisely, from only using desktops (or laptops) there will be technologies, that become more and more invisible, and that will be embedded in the environments. The technology disappears in the environment, but gets visible when it is needed. This is also to some extent already the case; more and more of the computers we interact with are embedded in devices. Weiser [23] defined ubiquitous computing as a “*new way of thinking about computers in the world, one that takes into account the natural human environment*” [pp. 94]. Central to his vision was interaction between humans and computers in a natural way, without the human subject thinking about it in any detail. Computers would become part of the background and indistinguishable from the fabric of everyday life. Computers are spread out in the environment and the user should get the feeling that she is interacting with the whole environment and not with separate computing devices.

By interactive spaces we mean environments that support collaborative work, co-located and distributed, where one has both public and private displays, and where there are many ways of working and sharing information with other people. One of the main strengths when working collaboratively in an interactive space is that one can easily share information with other group members. A common problem when looking at shared digital information is that only one or a few group members have an appropriate representation of the information displayed [13]. However, in a space where one has a public display this problem partly disappears. Only partly, since people can interpret the same representation in different ways, but nevertheless the representation is in public and open for all group members to inspect. The problem here is to make it easy to hand information over from personal to public displays. The metaphor we have worked on when designing the interaction in interactive spaces is giving/handing a document from one person to another.

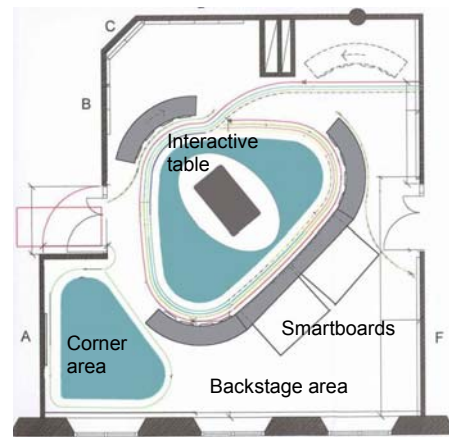
Further, this workspace offers several different ways of searching and presenting data, and there is also different ways of sharing it with other group members. When for instance having touch-sensitive displays one can interact with the computer with ordinary mouse and keyboard, but also using the fingers or pen to write, draw or navigate on the screen directly.

### **iLounge**

At the Royal Institute of Technology in Kista, Sweden, there is an interactive space called the iLounge designed and built with the purpose to support co-located collaborative work. It is used as a learning facility, both co-located and distributed, as an experimental research facility, and on a regular basis the room is also used for video conferencing. The room has two large touch-sensitive displays known as Smart boards [20] built into a wall. In front of this wall there is a table with a horizontally embedded plasma screen, also touch-

sensitive. This interactive table is large enough for 6 to 8 people to sit around it. In one of the corners of the room a smaller table and three chairs are placed in front of a wall-mounted plasma display, enabling a part of the group to work separately. Figure 1 shows a plan of the room. The room has a wireless network and laptops with wireless LAN card can be used. Keyboards and mice in the room are also wireless, using Bluetooth technique. Finally, the iLounge contains high quality audio and video equipment that for instance can be used when having videoconferences, or during user studies.

There are many computers in the room and it is also possible to bring personal artifacts into the room, and therefore it is in no way obvious how information is shared between the different work surfaces. To facilitate and support work in the iLounge part our research has been focused on the development of services that help and support the user to move data between the devices present in the room. Tipple<sup>1</sup> is a service with which one can open any file on any other computer that runs the Tipple service. The interface of Tipple shows icons representing all other computers running the service. If you want to start a file on another computer you drag the file icon to the icon representing the other computer (an early prototype is described in [24]). The service Multibrowse allows the user to move web content between displays in the room. When right-clicking a page or a link, the user is given the opportunity to “multibrowse” it either to or from its present location (see [8], for a more thorough description). PointRight makes it possible to use the same pointing device or keyboard on more than one computer in the room. When the pointer reaches the border of the screen it continues on the screen next to it having the service. PointRight together with iClipboard makes it possible for the user to cut or copy text between computers in the space. The text is placed on a clipboard that is shared by the computers running the service.<sup>2</sup>



**Figure 1: Plan of the room. The working areas are shaded.**

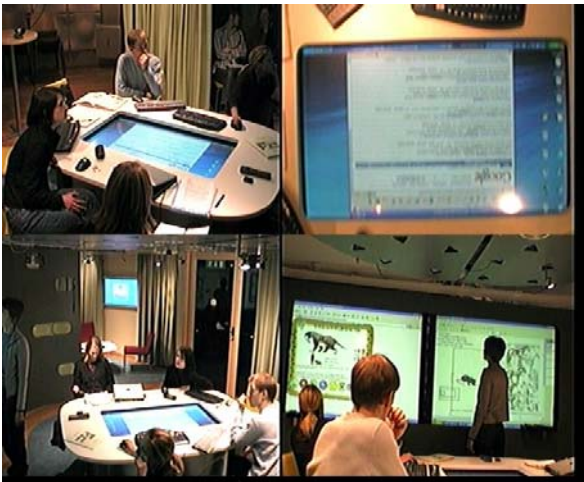
In the study reported on in this paper we also introduced some of SMART Technologies services to the participants, specifically the virtual keyboard and Smart Notebook. Smart Notebook is an electronic whiteboard application, where one can create documents containing typed text, hand-written text, and pictures. The document is visualized as a book with pages.

#### **METHOD**

Five students (one man and four women), in the ages of 21 to 45 participated in the study. A couple of them in the groups knew each other from before. The students attended a course in design of interactive systems at our department. Due to the course objective's the students should broaden their perspectives of methodology for design, and in particular for how to generate new ideas and solutions; to deepen their knowledge about design of interactive systems; to get knowledge about different criteria of good design in different domains and from these criteria be able to evaluate design of multimedia. The students' task was to design a digital, multimedia guide for the exhibition "4, 5 Billion Years - The History of Earth and Life" at the Swedish Museum of Natural History. The group was responsible for designing the multimedia guide describing "pre-historical mammals" (the mammals living before the primates). The target group was children about twelve years old. We followed the students during the conceptual design phase of their assignment. The conceptual design phase lasted two weeks and consisted of brainstorming, sketching of scenarios and the multimedia product, and information search. During this time the group had five sessions, in the iLounge. Prior to this, they received an introduction to the environment and the specific services introduced in section "iLounge". The group also had access to one laptop computer.

<sup>1</sup> Tipple is developed by the FUSE group, Stockholm University/ Royal Institute of Technology, and can be downloaded at <http://www.dsv.su.se/fuse/downloads.htm>

<sup>2</sup> Multibrowse, Pointright and iClipboard are part of the iWork package and are developed by the Interactive Workspaces at Stanford University. The iWork services can be downloaded at <http://iwork.stanford.edu/download.shtml>.



**Figure 2: The view of the video recordings with the four angles.**

Data was collected through observations, pre- and post-study questionnaires, and ended with semi structured group interview. The questionnaires have mainly helped us in the analysis of roles of the group members (reported in [13]). Both the work sessions and the interviews were video taped. The recordings consist of four angles to cover the whole workspace, see Figure 2, and one channel for sound. Altogether the data material consists of 12,5 hours of video data. As a tool for our analysis we have used Interaction Analysis [9], and more particularly certain foci for analysis, namely spatial organization of activity, participation structures, artifacts and documents, turn-taking, and trouble and repair.

### RESULT

The analysis focus on how the participants used the electronic whiteboards, how these influenced and supported their work when they did their conceptual design. A short description of the work process and the resulting multimedia guide, described in next subsection, will help understanding the excerpts and the discussion that follows.

### General Work Process and Design Products

During the first sessions the group focused on coming up with different ideas, and after three sessions they had eight design proposals. After negotiation, based on a evaluation, they agreed upon one of them. They brought children to the exhibition at the museum, tested the design proposals on children before deciding upon which of their proposals that should be chosen, as well as made a user test of the final multimedia guide. During the design process they continuously documented their work and the process itself.

The group designed a game that teaches about the pre-historical mammals. When the game starts, the user meets a researcher in a library. The researcher has documents about pre-historical mammals sorted in piles in accordance

with the era in which they lived. There is only one problem: the papers in the piles have become disorganized, and the task of the user is to get the piles in order again.

### Being Exposed in Public

To work in an environment that largely relies on the wall screens as a way to visualize information for the other team members was shown not to be unproblematic. To show information found at the Internet might be one thing, to be exposed in front of the others while drawing is another. The following two excerpts illustrate that it was a certain resistance to use the Smart board when it came to making the storyboard of their design proposals. Excerpt 1 illustrates that although the group had become acquainted with and used the Smart boards during the first session they still felt somewhat uncomfortable in using these during the second session.

### Excerpt 1: Session 2. Transition between individual and public<sup>3</sup>

Time	Transcript of interaction	Characteristic of action
0.12.55		
1, #3	“We can also put some picture here [in the Notebook]”.	Sits down. Looks at the right Smart board.
2, #1	“You mean, when we draw the proposals we can do it with the Smart...”	Looks at #3 sitting next to #1.
3, #3	“Mmm, but we can draw now. We have written down some things about what we want. I don’t know exactly what we are going to do now.”	Looks at the right Smart board.
4, #1	“Mm... We can do that.”	Looks at #3.

Here no one seems to be taking charge of the Smart board.

The following excerpt 2 (a continuation of excerpt 1) shows the embarrassment of going public – to be the one that is in focus of everyone’s attention. Here the Smart board appears to be more inhibiting, than supporting creative expressions. Note how #1 tries (line 8) to make the situation of being in public less dramatic.

<sup>3</sup> The transcriptions below are divided with resemblance to the work of [16]. But in our case “Characteristic of action” describes the actor’s action, not the abstraction of the utterances.

**Excerpt 2: The embarrassment of going public with ones drawings.**

Time	Transcript of interaction	Characteristic of action
0.21.05		
1, #3	“But if one draws something under here [shows with the pointer]. Or to make some more space.”	Points with the pointer in the Notebook, on the right Smart board.
2, #4	“Hm...”	Looks at the right Smart board.
3, #3	“Some screens or something or... [refers to the design of the multimedia guide]”	Looks at the Notebook.
4, #4	“Yes. Is anybody good at this, to draw?”	Looks at #3.
5, #3	“I am very bad...”	Works with the Notebook.
6, #5	“So am I.”	Looks at a Word document on the left Smart board.
7, #4	“There are others...”	Looks at #3.
8, #1	“On where? There? [points to the right Smart board] It is just to go there and draw with the hand.”	Points at the right Smart board.
9, #4	“Yeah, right! If... Is there anybody with some talent of drawing?”	Looks at #3.
10, #5	“We don’t care about how the animals looked.”	Looks first at #3, then at the left Smart board. Talks simultaneously with #1, line 12.
11, #5	“What are we supposed to draw?”	Looks at #2 and #3. Talks simultaneously with #3, line 13.
12, #2	“Draw pictures of a screen with all the animals, maybe. It is just to make some dots.”	Looks at #5.
13, #4	“Someone with some talent of drawing.”	Talks at the same time as #2, line 16. Talks to #1.

They solved the problem of drawing in public through ripping pictures from the Internet and by making simple symbols, as squares and circles, signifying animals. This was done using two Smart boards in parallel, one for using the Internet and one for using the drawing program. In this way the idea generation and other processes of

creativity were not interrupted through the embarrassment of going public. It also shows the interdependence of two seemingly independent processes: the relation of how the workspace layout is supporting creative solutions and creative use of symbols in collaborative activities.



**Figure 3: Session 2, time: 0.46.43. Pictures complemented with hand drawn images.**

Later on they did not think of the appearance of the drawings, and mixed inserted pictures and pictures drawn by hand, see Figure 3. This shows that inserting pictures was a way to overcome the fear of being exposed to the others.

**The Electronic Whiteboard as an Entrance to the Collective Memory**

The electronic whiteboard could also be used as an entrance to the history of the design and the process of idea generation, and in this way function as a collective or shared memory. Excerpt 3 illustrates how the digital whiteboard is used for creating a common understanding of the design proposal. In the previous session, #2 was not there, and at this session he has arrived a couple minutes before the others. While waiting for the others he is looking through some documents created during the previous session.

**Excerpt 3. Session 5. Catching up the ideas from last work session.**

Time	Transcript of interaction	Characteristic of action
0.04.12		
1, #1	“Have you had time to check what we have been doing?”	#1 looks shortly at #2.
2, #2	“Yes. It was...”	#2 looks and opens the shared folder on the left Smart board.
3, #1	“Wow! Good. How good. Ambitious.”	Sits down.
4, #4	[Clears her throat.]	Opens a can of coke, and looks at the left Smart board.
5, #2	“You might be able to explain as well if you want.”	Opens the Notebook document that the

		others created last time.
6, #3	“Well, it might be necessary with some explanations.”	Looks at #2, than on the left Smart board.
7, #1	“Do you mean...Do you mean that? (laughing) Aren't they self explainable?”	Looks at #2, and laughs friendly.
8, #2	“Well, they are that, but just some details...”	Looks first at #2, than back on the left Smart board.
9, #2	“What is it meant by, in this part, [points with the mouse] ‘if someone is getting closer to subject picture...?’”	Uses the mouse to point at an inserted text piece in the storyboard, and follows the quote with the pointer.
10, #4	“If someone is, well... If you think someone is standing on a screen. Well, we haven't solved that yet...”	Looks at #2.

The notebook document here supports and facilitates discussing the work the group did during the previous session, and also of creating a common understanding and building a shared picture of the work. Not only #2, who was not there during the last session, asks for further explanations. Also, #3's confession about the need for explanations (line 6) and #1's laugh and question about the meaning of the drawings (line 7) gives witness to this. For those who were there the last time it is also a catch up to get back to the discussion that was held during that occasion. They spend the following ten minutes explaining the storyboard for #2. #2 is the one asking questions, and is also being in charge of the Notebook document. He goes through all the pages in the Notebook to get the whole picture of the story for the multimedia guide. During the session they continue to work on the storyboard, and the design of the multimedia guide to make it even more concrete and specified, with pictures, and text pieces.

Mediating and explaining earlier accomplishments to members who have not been involved during earlier sessions here provides with obvious learning benefits. Also, this example can be viewed upon as a repository of earlier arguments and design decisions. Having to recapitulate the discussions and decisions made during the previous session provides with an opportunity to practice on arguing for choices and decisions that have been made. Of course these decisions are not carved in stone but can be re-negotiated when new interpretations, design considerations and ideas become evident. As such the Smart board and the public notations seem to be a very important and effective tool.

The following excerpt is a continuation of the last one, more than one hour later. At this moment, at their last session in the iLounge, they are very focused on the final design solution. At the start of excerpt 4 they are all sitting around the table. #2 has manipulated some pictures in a Notebook document open on the left Smart board. #4 uses the laptop. At about line 6 #1 starts searching for information on the Internet, and uses the computer that is built-into the table for that purpose.

**Excerpt 4: Negotiation about how to create the pictures in the final design solution.**

Time	Transcript of interaction	Characteristic of action
1.18.00		
1, #2	“Ok and...?”	Shifts the look from the Smart board to the people around the table, and uses the mouse to point in the Notebook.
2, #3	“Well, this... I think we should paste pictures of ‘real animals’, and make a nice time line so they get it.”	Looks at the other team members.
3, #1	“We need to fix this a bit. [Inaudible] real research.”	Looks at the left Smart board. Talks simultaneously with #3, line 2.
4, #4	“Mm... we should do that.”	Looks at the others.
5, #3	“This looks a bit rickety.”	Talks simultaneously with #3, line 6.

Here #3 raises an issue of the appearance of the presentation, and the focus of the group shifts from focusing the conceptual design to focusing the appearance (the aesthetics if you will) of the multimedia guide. In the following the discussion continues in trying to resolve this issue.

**Excerpt 5. Continuation of Excerpt 4.**

Time Cont.	Transcript of interaction	Characteristic of action
6, #2	“Hm... But it is a bit like... in pasting, in pasting such pictures and stuff, and you want it to look good, you have to spend a lot of time to...”	Looks at #3, and shortly at #4.
7, #3	“Yes, but...”	Looks at #2.
8, #2	“...edit them. I think we might as well draw: or like this, to pretty much	Looks at #3.

	do like this..."	
9, #1	"Here one can see mammoths that look like mammoths in the surroundings."	Looks at a web page on the table computer with pictures of animals.
10, #3	"I think... I think one could cut and paste a bit..."	Looks at the other team members. Talks simultaneously with #1, line 9.
11, #4	"Can't we just find some picture with a lot of animals..."	Looks at the other team members.
12, #2	"Mm..."	Looks at #4.
13, #3	"Yeah..."	Looks at #4.
14, #4	"...and paste it for the time being?"	Looks at the laptop.
15, #3	"Yes."	Looks at #4.
16, #4	"...so that it look like a landscape with animals and everything."	Looks first at the team members, then at the laptop.
17, #3	"Exactly."	Looks down.
18, #2	"Yeah, right. Do you remember that first page that we... it was something about games for children...it was one of those..."	Looks at #4.
19, #3	"Yeah."	Looks at #2
20, #4	"Mm..."	Looks down.
21, #2	"...with different animals."	Looks at #4.
22, #4	"...but can't we...?"	Looks at #2.
23, #2	"And then it will be sorted under our..."	Looks at the left Smart board.
24, #3	"Our pictures, right?" [compare this to the folder "My Pictures" in Windows]	Looks at the left Smart board.
25, #2	"No..."	Opens "My Computer" on the left Smart board.

After opening "My Computer" #2 opens a word document, where they have a link to a picture. He opens the link in a web browser, and they discuss the picture.

The excerpt illustrates how their different ideas about how the animals in their multimedia guide should be represented, and how the documentation from an earlier work session becomes the entrance for them how to solve the problem. The document functions as a collective memory of earlier discussions and negotiations, which they all previously have agreed upon and now have access to. It becomes an important source for them not to get stuck in the design process. And also, the digital

representations give the users the chance to re-negotiate and re-represent the design proposals. This discussion is facilitated by an easy access to Internet, digital representations of animals as well as a shared surface for projection.

## DISCUSSION

Learning to work in an interactive space, and learning to design multimedia products, is two different activities. From a student perspective the goal of the work was primarily to fulfill their task of creating and designing a multimedia product for the museum, and secondly to learn how to use the environment.

One of the greatest advantages with using large screens is that everyone has the possibility to see and share the information. Another advantage, as shown in excerpt 3-5, the electronic whiteboard can support the users to get back to information (in this case the sketches and storyboards), and in this way construct a shared memory and also based on this shared memory to re-construct previous discussions and justifications for decisions that have been made. Similar interpretations have been made by [14], where the authors discuss awareness support of collaborative processes and features of such a tool in order to represent work processes in collaborative teamwork. On the other hand it is only possible for one person to work at a time, since the system does not support more than one user. Due to this, the way turn-taking can take place changes. In relation to Löwgren and Stolterman's [12] discussion on sketching a collaborative environment changes the individuals' design space and possibilities to come to expression. When changing educational practice towards more collaborative accomplishments and teamwork, design theory and the scrutiny of sketches must change accordingly.

When entering a workspace, or any other space, we bring our earlier experiences and expectations with us. In the pre-test questionnaire we asked the students if they had any experience of using a Smart board or similar technologies, and no one had that. In this case this means they did not only bring their social conventions of how to act in a group with other people; they also brought their earlier knowledge of how to work when using standard resources, such as whiteboards, computers, papers and pencils for design tasks. And even though most software resources in the environment are standard Microsoft® products, the way the resources supports the user(s) are very different from what they are used to. The services (presented earlier in the paper) support navigation between the different screens, and the several wall screens supports the way the users can visualize information for everyone to see. The students grasped the basic functionalities, but new functions in the environment concerning both the general pointing devices and for sharing of information (or rather sending information to different screens) were difficult to grasp. Further, the students did not spend any time exploring the workspace into any detail, which indicates that it is necessary to have an even more thorough

introduction to the environment and to explicitly encourage users to spend time exploring the environment (the computers, screens and services).

The facilities in the workspace support the creation of information and the use of resources in different ways. It is possible for users to contribute on the joint work in parallel, as illustrated in Excerpt 2. How the users choose to use the artifacts, and who is doing what when, is dependent on the formation of the group and the social conventions the users have learnt before, and “bring into” the workspace [7].

In this study we did not want to govern the students’ work, but rather we wanted to conduct an open study into how this environment supports collaboration and learning. In light of this, the problem is not that the students did not use the artifacts in some optimal best way (if there is one), since they used the services that were introduced to them, but rather that the students did not explore the workspace any further. This indicates that, on the one hand it is important to make the positive qualities of the environment more visible to the users – to strengthen the affordances. On the other hand, we do not think that strengthening the affordances will be enough. This environment differs from other workspaces and computer supported environments in the sense of not just having desktops and e.g. whiteboards. But to give users of this environment a fair chance of taking advantage of the functionalities in it, a method, or guide for how to work in this kind of environment is called for. This could be done through exemplification of ways to use the technology, and to stress the importance of exploring the use of the artifacts – only through use of artifacts and tools the knowledge about the technologies will be revealed as to how it supports different activities, and it is also through the use that insights can be made and come to expression.

#### ACKNOWLEDGMENTS

This work was in part sponsored by the Wallenberg Global Learning Network through the iSpaces Project (partners in the project are Royal Institute of Technology and Stanford University) and in part by the DeKaL-project (The Swedish Science Foundation). The Wallenberg Foundation has financed the equipment in the interactive space. Finally we want to thank Maria Croné and Johan Mattsson at DSV, who participated as systems designers and in conducting the study.

#### REFERENCES

1. Brown, J. S., (1990). Towards a New Epistemology for Learning. In: Frasson, C. and Gauthier, J. (eds.), *At the Crossroads of Artificial Intelligence and Education*, Norwood, NJ: Ablex, pp. 266-282.
2. Brown, J. S., Collins, A., and Duguid, P., (1989). Debating the situation - A Rejoinder to Palincsar and Wineburg. *Educational Researcher*, 18(4), 10-12, 62 (1989).
3. Collins, A., Joseph, D., and Bielaczyc, K., (2004). Design Research: Theoretical and Methodological Issues. *The Journal of the Learning Sciences*, 13(1), pp. 15-42. Lawrence Erlbaum Associates.
4. diSessa, A., and Cobb, P., (2004). Ontological Innovation and the Role of Theory in Design. *The Journal of the Learning Sciences*, 13(1), pp. 77-103. Lawrence Erlbaum Associates.
5. Engeström, Y. (1987). *Learning by expanding: An Activity-theoretical Approach to Developmental Research*. Helsinki, Orienta-Konsultit Oy.
6. Engeström, Y., Miettinen, R. and Punamaki, R.-L. (Eds.) (1999). *Perspective on Activity Theory*. New York: Cambridge University Press.
7. Hutchins, E. (1995). *Cognition in the Wild*. Cambridge, MA: MIT Press.
8. Johanson, B., Ponnekanti, S., Sengupta, C., Fox, A. (2001), “Multibrowsing: Moving Web Content Across Multiple Displays”, In *Proceedings of Ubicomp 2001*, Atlanta, Georgia.
9. Jordan, B. and Henderson A. (1995), Interaction Analysis: Foundations and Practice, *The Journal of the Learning Sciences* 4(1), pp. 39-103. Lawrence Erlbaum Associates, Inc., 1995.
10. Kuutti, K. (1996). Activity Theory as a Potential Framework for Human-Computer Interaction Research. In Nardi, B. (ed.), *Context and Consciousness: Activity Theory and Human-Computer Interaction*. Cambridge, MA: MIT Press, pp. 17-44.
11. Lave, J., & Wenger, E., (1991). *Situated Learning: Legitimate Peripheral Participation*. R. Pea & J. S. Brown (eds.), Cambridge University Press. (1991).
12. Löwgren, J. and Stolterman, E. (1998). Developing IT design ability through repertoires and contextual product semantics. *Digital Creativity* 9(4), pp. 223-237.
13. Mark, G., Kobsa, A. and Gonzalez, V. (2002), “Do four eyes see better than two? Collaborative versus individual discovery in data visualization systems”, in *Proceedings of IEEE Sixth International Conference on Information Visualization (IV'02)*, London, July 10-12, 2002. IEEE Press, pp. 249-255.
14. Pankoke-Babtz, U., Prinz, W. and Schäfer, L. (2004). Stories about Asynchronous Awareness. In Darses, F., Dieng, R., Simone, C. and Zacklad, M. (eds.), *Cooperative Systems Design – Scenario-*



- based Design of Collaborative Systems*, pp. 23-38. Amsterdam, IOS Press.
15. Pea, R. D., (1992). Augmenting the Discourse of Learning with Computer Based Learning Environments. In: E. De Corte, M. C. Linn, H. Mandl & L. Verschaffel (eds.), *Computer Based Learning Environments and Problem Solving*, NATO-ASI series, Springer Verlag Berlin Heidelberg.
  16. Pomerantz, A. & Fehr, B.J. (1997) Conversation Analysis: An Approach to the Study of Social Action as Sense Making Practices. In van Dijk, T. A. (ed.), *Discourse as Social Interaction*. London: Sage Publications, pp. 64-91.
  17. Ramberg, R., & Karlgren, K., (1998). Fostering Superficial Learning. *Journal of Computer Assisted Learning*, 14, pp. 120-129.
  18. Reiman, P., (2003). Commentary: Multimedia Learning: beyond modality. In Mercer, N. (ed.), (Schnotz, W., & Lowe, R. guest editors), *External and Internal Representations in Multimedia Learning*. Learning and Instruction, vol. 13 (no.2), pp. 245-252.
  19. Rogers, Y. and Ellis, J. (1994). Distributed Cognition: an Alternative Framework for Analyzing and Explaining Collaborative Working. *Journal of Information Technology*, vol. 9, pp. 119-120.
  20. SMART Technologies: <http://www.smarttech.com>. URL last checked May 17th, 2004.
  21. Suchman, L., (1993). Reponse to Vera and Simon's Situated Action: A Symbolic Interpretation, *Cognitive Science*, 17 (pp. 71-76).
  22. Sundholm, H., Artman, H. and Ramberg, R. (2004). Backdoor Creativity – Collaborative Creativity in Technology Supported Teams. In Darses, F., Dieng, R., Simone, C. and Zacklad, M. (eds.), *Cooperative Systems Design – Scenario-based Design of Collaborative Systems*, pp. 99-114. Amsterdam, IOS Press.
  23. Weiser, M. (1991), “The Computer for the 21st Century”, *Scientific American*, vol. 265, pp. 94-104.
  24. Werle, P., Kilander, F., Jonsson, M., Lönnqvist, P. and Jansson, C. G. (2001), “A Ubiquitous Service Environment with Active Documents for Teamwork Support”, in *Proceedings of Ubicomp 2001*, Atlanta, Georgia.