INTRODUCTION

With the fast technology development traditional techniques of human activities are turning into digital, supported by new devices. In this paper we are specifically focusing on sketching as an unavoidable part of architectural design in the initial parts of the process, as was investigated in previous research by Novakova, (2011). We are observing collaboration over distance between two separate groups of students working under different conditions. Using sophisticated systems our collaborative setting introduces obviously some technical issues and puts emphasis on the shared medium between the students.

We are setting up an experiment with two groups of architectural students cooperating over distance. Faculty of architecture Czech technical University Prague (CVUT) is meeting Department of Architecture Eidgenossische Technische Hochschule (ETH) Zurich using PragueLab (PL) and ValueLab. The equipment at each place tested differs, therefore our test proves the compatibility of ETH state-of-the-art systems of collaboration, consultation and education (Halatsch, Kuntze and Schmitt, (2009)) and the more common, low-tech set-up of FA CVUT. Not only the experiment results in finding a working scheme for collaboration using different types of device, programs and teaching schemes (Figure 1), but it comes up with a new application supporting intuitive sketch exchange in the initial phases of architectural design.

For Students: Sketching Apart Together

A collaborative seminar focused on architecture studio education

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Abstract. The paper describes a possible way of teaching design studio over distance. Diverse experimental settings in terms of using different technology were tested with a group of students located at remote places. In this paper we describe the use of high sophisticated collaborative technology such as Value Lab in combination with ordinary computing equipment on an individual basis such as Prague Lab. It points out the advantages and weaknesses of both Labs. The aim is bringing facility and transparency into remote collaborative process in order to implement them into regular architectural studio education. Authors developed new application “ColLab sketch” in order to understand, simplify and facilitate digital sketch processes on diverse platforms.

Keywords. Architecture studio education; remote collaboration; Value Lab and Prague Lab; sketching; touchscreens.
We are using three scientific methods in the experiment during the collaborative seminar: A questionnaire for the participants, observation of behavior and experiments with the devices (PQLabs multi-touch overlay, iPad, Vacom). We are also testing the programs for teleconference meetings. (Adobe Connect, Skype, Oovoo, FaceTime, CoLabsketch). The ergonomic aspects regarding the size of touch screens for sketching and surfaces for presenting are also an issue. In the end, we propose a working scheme, which is independent of concrete technological settings and can be adopted by groups as well as individual coworkers.

PREVIOUS RESEARCH
The potential of computers for collaboration in architectural education – as discussed in literature – was elaborated at ETH Zurich by Dr. Gianni Birindelli within an experimental course called “mt_EAST” that was held between 2007 and 2009. Besides didactical interests in students teaching themselves with tutorials about the new technology, its main purpose was to explore how to integrate these new communication technologies in normal design studios. The participants were equipped with an eTable in order to exchange designs individually or in groups. Sketching, file and picture exchange, video chat were all supported through a Software called “Marratech”, which unfortunately isn’t sold anymore.

Firstly, we made a preliminary research on sketching in architectural design to anchor the presumption that it is not possible to bypass it in the architectural practice and thus education (Novakova, Achten, Matejovska 2011).

Secondly, previous research in the field of computer supported collaborative work (CSCW) as well as in virtual design studio teaching (VDS) gives groundwork to our hypothesis and posts new challenges. (Wojtowicz 1994) writes with enthusiasm: “Scanned hand sketches are an excellent way of sharing initial ideas...” and “There is a conflict between the natural ambiguity of design while engaging the demanding structure of the machine. There is a desire for a non-deterministic design counter-balanced by a need of collaborative coordinated opus.” In collaborative design the problem of authorship seems to be of a significance: “designer has to give up privacy protecting his or her own design process...” Based on Wojtowicz preliminary research Kolarevic (2004) made an experiment with virtual design studio, which took one week and was spread in 3 time zones. They solved the problem of authorship by tracking the individual contribution to the project with a database. And as well the authors bundled the individual pieces of work into common designs: students exchanged projects at the beginning of each design phase. The resulting designs are of shared authorship, but the individual work is traceable.

Hypothesis
We derived from preliminary studies that for collaborative design sketch support is important. With our Architectural studio experiment we want to observe, how much do the students need sketching in collaborative architectural design process.

Furthermore we test the possibility of linking systems for collocated collaboration (ETH Value Lab) with other systems on individual basis.

PROCESS OF AN ARCHITECTURAL STUDIO
Experimental design studio has two-year tradition (Novakova 2010). The idea is to test new methods/technologies in education together with students. It is based on collaboration, discussing unusual topics and the use of internet. This semester we focused on remote and collocated collaboration in the initial phases of designing and in communication with the use of different technology.

Architectural studio is the most important part in the life of a student of architecture, where he/she learns the actual procedure of an architects work. Basically it was and is always based on the experience and knowledge of the Lecturers - architects and by repeating their methods the students get familiar with the process. Within this procedure getting familiar with various attitudes enlarges the students possibilities followed by abilities. This is why
students are recommended to switch between lecturers during the study.

Now the process of design went through some important changes as the technology improved. Creating plans and visualizations has speeded up as well as document sharing and communication. There are common communication media such as audio and video technologies (teleconferencing), which is being used worldwide. We focus on the architectural sketch communication, a part of the lecture-design-presentation cycle, which appears in loops. Communication of two/more architects differs from the regular video + audio communication. As long as architects are visual thinkers, who need to express their ideas verbally as well as visually, they require a medium additional to regular communication media mentioned earlier. They need to sketch when explaining their ideas.

Design studio is usually divided into three parts: Introduction and analysis, creating the design and finally representation of the design together with a critique. These phases may repeat in loops every three or four weeks. We presume communication by sketch is needed nearly every time during the loop and is essential.

In the first part of the design studio the topic, the site and the problem is usually described by the Lecturer. In the two or three coming weeks of ANALYSIS the students collect information about the task and could also share and extend this visual information by discussing it graphically.

The period of DESIGNing architecture is the most sketch-demanding part of the Studio. Students try to visualize their inner visions and present them to their colleagues. The fastest way of sharing and explaining these visions in the initial part of the design process is sketching. (Ullmann, Goldschmitt) And even after modelling in CAD programs has started, the corrections and variations of the design are to be made by hand during the discussions and critiques. It is the fastest and “handy” means of architects and designers communication.

In the phase of PRESENTATION the ready design is shown to the supervisor. Posters are usually printed and students try to defend their ideas, drawing into the printed posters is not exceptional. Again here the intervention with the hand sketch is used to clarify the ideas, underline the important places and change the shapes of buildings. A discussion can appear, where one line follows another.

**Figure 1**
Architectural studio phases in regular consequence showing the number of screens used.
As mentioned above, sketch communication is unavoidable in any part of the design teaching process. When we want to perform a distant lecturing and collaboration of high quality, we need a tool to use with appropriate software and technology. This allows us to accelerate the teaching process. We can have distant collaborative groups of students, who exchange their ideas in real time. In this process we can share the knowledge over long distances without an expense.

THE STUDENTS, THE TASK
Six Students in Prague, Faculty of Architecture CVUT and four students in Zürich, Department of Architecture, ETH took part on the collaborative course FOR GARBAGE.

The task was following: How can the domain of architecture contribute to solving the garbage problem of the world? Students were required to develop a strategy resulting in design or 1:1 prototype. After an analytical part students accepted the offer to work on PET tower design, and started to develop ideas in teams. The seminar had 10 lectures 3 hours each. Although there was a trial to create dislocated groups, local teams were naturally formed and students gave each other critique over distance. The instant remote idea development took place when designing a logo for the whole project. While in Zürich students went from individual contributions through teams of two to final 4 member team, Prague participants ended in the stage of 2.

EQUIPMENT

Prague Lab
The lab in Prague was assembled uniquely for the purpose of this seminar and used for the first time.

The PL is a dedicated room for collaborative design sessions. The means for establishing the collaboration are: Core 2 Duo, 2GB RAM, Radeon GPU computer, with Windows XP. Later, we upgraded to another Core 2 Quad, 4GB RAM, Quadro 3600 GPU, Windows 7 64bit, which shows we work with standard technology as much as possible and with free versions of software. The technology consists of regular PC’s with Internet connection, equipped with high-quality web-cam, microphone, tablet and sound system. A monitor and a LCD-projector provide two different screens: one running the collaborative system from ETH, one showing the people from Zurich. Additionally, two iPads function as additional camera/video transmitters. Their advantage is that they are mobile and can be held and placed at any location thus making the visual communication much more dynamic and attractive. The challenge between ETH and CVUT was to see whether we could link the different platforms and technologies.

We have seen that the equipment of both institutions differ. On the Zurich side, the facility can serve the collocated co-workers interactively, it is a team equipment. On the Prague side the facilities are rather focused on individual use and are put together in order to perform the team cooperative studio room. In the future, the device setting can be split into single distant units, ColLab sketch applications’ single user interface will come to use.

Value Lab
The Value Lab is a conglomerate of different high-end technologies installed in a well designed large room (80m2, 6m height). The video display possibilities include three wall-mounted 82” multi-touch-screens, two horizontally, table-like installed 65” multi-touch-screens and three projectors. As a video source users can bring their own laptop or use the two high-end computers installed next to the Value Lab that let the users also benefit from the multi-touch capability of the screens. The VL is equipped with a Tandberg video conferencing system that includes two zoom-able high quality cameras. Its video signal can be routed to the VL displays as well. All video signals can be recorded with a separate computer running a live video editing software, that cuts two different channels in real-time.

To control all of these possibilities the Value Lab is equipped with an iPad that runs a custom AMX interface software. It lets users not only control
### Table 1

**Number of students at the start and end of the session.**

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**Figure 2**

*Equipment in the team rooms (upper picture) with the use of them (lower picture).*

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**Value Lab**

The VL is being used by chair of iA for teaching in the domain of urban planning. Rather than by studios, the room is occupied by sessions with collaborative character and urban design courses, where multitouch tables are used to sort (drag and drop) images, view and manipulate big scale maps etc. It occasionally serves to an architectural studio for teleconference, critique or presentation thank to its large screens and high quality teleconferencing system.

**Prague Lab**

**Innovation**

Together with upper mentioned technology we tried to bring an innovation into the sketch collaboration by developing a new application for sketching. The aim was to develop easiest system possible for sketch collaboration in terms of communication and collaborative idea development (“sketch-storming”). We wanted to disintegrate de-
sign process from other influences. The focus was upon preserving intimacy but bringing a new value to VL. A bright new application called CoLab sketch was consequently developed after observing the students needs. In the lesson 5, basic no-function interface was offered in Zürich. Students were observed, what tools apart of line-drawer they were missing. In the next lecture we added thickness difference and found out, that the students would rather use the thicker lines than thinner and that they avoided switching between thicknesses. Next, we added shades of gray color picker, but when sketching during communication students used only the darkest line possible. Finally, opposite to the anticipation, the students missed “eraser”, “delete” or “back” function.

Students supplied “eraser” with thick white pen and perfect sketch exchange was performed. By creating an easy explanatory sketch and dragging it into the middle stripe, students could “publish” their drawings. Once they were published, any co-worker could drag them from “public” middle stripe to is own plane, edit it and vice versa. A new problem appeared: the remote collaborators could not directly react on the sketches because they were not able to follow the authors explanation. They only could download a ready “published” sketch. We solved this problem by adding a new function: life preview (one-way share) and shared whiteboard (both ways share). Now students can not only sketch privately and publish the ready drawing, but also sketch live in “public - preview” or even offer their board for si-

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<td>3 2 projectors/ Face-time</td>
<td>3 wall touch-screens, iPad/ Face-time</td>
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<td>4 1 projector, 1 monitor, 1 iPad/ Face-time</td>
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<tr>
<td>5 1 projector, 1 monitor iPad/Oovoo</td>
<td>2 wall touch-screens, iPad, 1 touch-table, Oovoo, CoLab</td>
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<td>6 1 iPad/Skype, CoLab</td>
<td>2 wall touch-screens, 2 touch-table, Skype, CoLab</td>
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<td>7 1 projector, 1 monitor1, iPad, tablet/Skype, CoLab</td>
<td>3 wall touch-screens, 1 touch-table/Skype, CoLab</td>
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<td>8 1 projector, 1 monitor1, tablet/Skype, CoLab</td>
<td>2 wall touch screens, 1 touch-table/Skype, Adobe Connect, CoLab</td>
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<td>10 Adobe Connect, CoLab</td>
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Table 2
Equipment of PL and VL.

Figure 3, Figure 4
No-function interface and the multi-user version of CoLab sketch (shades of grey, thickness of line).
multaneous sketching. By dragging them to “public” sketches are saved.

Together with testing the system in VL on multi-user touch-tables a single-user interface was developed. This interface reacts on mouse left (draw) and right (drag-and-drop) click. So if there is no touch device in private sector, students can take part even with a regular desktop equipment.

The 8th and 9th session showed the need of sketch critics of ready visualizations. As a reaction we added the function of uploading files as an underlay to the sketch plane with preserving all previous functions. To overview and delete the uploaded sketches, administrator interface was created. This is only accessible by the leader of the session.

**OUTPUTS OF THE EXPERIMENT, DISCUSSION**

While our colleagues (Maher, Bilda, Marchant) made pilot studies of the set-ups for their experiments and gave training sessions on the use of the software, our aim was opposite: we aimed at observing, if our students intend to sketch on the prepared multi-touch surfaces naturally and if our software creates an obstruction to a lay user.

**Role of sketching**

For the purpose of clear overview of activities in the sessions we specified three actions of the studio: presentation (p), discussion (d) and collaborative design (c).

From this table we can see that graphical communication (with ColLab sketch) was used in the middle phase of the studio and continued towards the end. Furthermore, more than half of the sessions engaged sketching. Video recordings were taken at every lecture, which showed the students’ need of sketch communication. Even a layperson
when explaining the task looked for a sketch device.

The group of students on Zürich side was more active than on the Prague side. The equipment of the VL supported easy sketch contribution for all the four participants at a time. We observed the decrease of the number of students on Prague side during the design phase, which we subscribe to the impossibility to participate with sketch easily.

**Technical issues**

There was a number of technology problems, which repeatedly discouraged students from using either the touchscreen or the tablet. In the VL 1,5cm impreciseness was found as a major obstacle by the touch-table, where calibration failed constantly. But even if the touch-table was calibrated, it is impossible to create a circle smaller than 1,5 cm in diameter due to its infra-red-net construction solution. From the user observation we derive results shown in Table 4, where precise sketches were used for sections, details etc. Performing it took too much effort with unsatisfactory outputs. On the other hand informal explanatory sketching (letters, pointers, gestures) by a lay person went great.

The speed of the line, resp. how fast does the computer reply to the “touch and move” of the finger was also not without significance. In the beginning, sketching on touch-tables was frustrating for the students for their high expectations. The easy interface showed clearly and instantly the imperfection of technology.

Using a tablet needs training. Drawing elsewhere than looking, together with the rotation of the screen is an obstacle. Students in PL were not able to react on the discussion in time, too much focus was dedicated to operating the device. We also had two Ipad 2 16GB at our disposal as mentioned above. First, we experimented with using them as a close up camera-microphone for the actual speaker, but we ran into sound-loop and echo issues so we abandoned the idea. After that we tried to use them as additional computer screen and touch-screen. That was more promising, screen worked well and provided our session with the 3rd screen. Our further development of ColLab sketch goes forward to its usability on small touchscreens like iPad.

As input devices we used mostly mice and in the 7th lesson we added Wacom tablet, which substantially improved sketching experience taking it close to touchscreen. The disadvantage was “looking elsewhere than drawing” and single-user mode of this device. Adobe connect was used for shared presentations but was not implemented in “sketch-storming” due to slow refresh render and lack of “private” areas.

**Our solution and discussion**

Sketching is important in collaborative design studio over distance. It has basically two functions: firstly, informal direct communication, secondly, precise explanation and development of ideas. The first mentioned process can be performed on an imprecise technology, the second one needs a device of high precision.
In our experiment we proved that it is possible to link VL with a low-tech system (demonstrated by PL), using the multi-touch tables and screens for co-located together with dislocated collaboration. Though, the VL room-system is complex and takes 2 people to run smoothly all the above mentioned interactive processes (1 teacher and one technical support). The Optimal Team Room setting is dependent on the number of co-workers. In our study we observed that the more facile the setting is, the more flexible it is. We propose combination of more independent, but high quality interfaces in order to run different sessions with different topics and different participants. The sketching surface needs at least “one-screen” space per person as well as the video per group. When communicating, architects not only sketch, but also “sculpture” ideas with their hands. Thus it is important that all the three channels (audio, video, sketch) are of high quality in terms of resolution and size. The optimal combination was Skype on big screen(s) for audio-video conferencing and independent application for presentation share and sketching like Adobe Connect and ColLab sketch on the touch-devices. Although Oovoo fulfills all requirements and has additional functions, renewing our directory of connections was a constraint.

ACKNOWLEDGEMENT
We acknowledge both Chairs (Chair of iA and Molab) and their members for technical support of the project. Christine Meixner contributed to the initiation of the ColLab sketch development and Vladimir Jakubal (with his IT skills independent of programming languages) was able to program an application for multi-touch table at a distance without the device itself.

REFERENCES
Maher, ML, Bilda, Z and Marchant, D 2005. ‘Comparing Collaborative design behaviour in remote sketching and 3D virtual worlds’ in S. Gero, Lindemann, Human behaviour in design 05, NSW : Key Centre of Design and Computing and Cognition, University of Sydney.
Pia, B 2002. From CAD to communication: Connecting the real and the virtual, Aarhus School of Architecture, eCAADe, Warsaw, Poland.
Wojtowicz, J (Ed.) 1994. Virtual design studio, Hong Kong University Press, Hong Kong.
[3] www.ia.arch.ethz.ch/