

A Next-Generation Interactive Whiteboard for Educational Settings

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ABSTRACT

Interactive Whiteboards (IAWs) are an integral part of 21st century learning environments. In this submission we present a new technological approach to the implementation of an interactive whiteboard based on HD equipment. In specific, the proposed whiteboard system architecture utilizes state of the art components for a high definition rear projection. We will describe various aspects of integration of HD-based equipment and its usage for Interactive Whiteboards. Suitable means for interaction and for flexible utilization of the projection system are crucial, and we will introduce some novel concepts supported by our system. Based on the description of this system, we will discuss technological aspects of a next-generation IAW. We demonstrate, how to bring IAWs and different media signals together to one system. The aim is a central remote control unit, which can be used by teachers and students easily. Last not least, we will discuss educational aspects of the opportunities for use of whiteboards. This discussion will be based on first experiences in teacher education using the system.

Keywords: Interactive Whiteboard, Rear Projection, Teacher Education, Full HD, Remote Control

1. INTRODUCTION

Interactive Whiteboards (IAWs) have been proposed for a long time as an effective tool in classrooms. There have been a number of initiatives to foster the installation and use of such systems at schools in Europe. There have already been perceived advantages in the use of IAWs in mathematics teaching in the United States [1]. This was also shown by Greiffenhagen [3] and Glover and Miller [2]. Also, IAWs are an integral part of learning environments of the 21st century [5].

The idea to build a classroom as it could exist in 20 years has been our motivation for looking for an improved whiteboard technology. Current IAWs used in school improved in functionality over the years, but still, since several years the same technologies for projection and interaction are used. Further, these technologies have some deficits concerning image resolution, contrast, and interaction. As well, projection from the front leads to occlusion of the presentation, which is due to the thrown shadow of the teacher. In addition, nowadays media sources comply with modern digital standards that do not automatically integrate into analog systems. Our system, we named *Lernlabor*, integrates a state of the art Full HD 1080p rear projection with digital image processing that sup-

ports all different kinds of digital and analog electronic media. The scalability and the modular design of the *Lernlabor* system is an important feature to include other technologies that should be supported in the future. To our knowledge, our system is currently unique in Europe. In the following, we will discuss the system architecture and several system features. We also provide first results from application in educational settings.

2. THE LERNLABOR SYSTEM

The system we built is located in a room which is divided by a wall in two parts, the engineering room and the class room. In the partition wall, the projection pane based on a 270 cm x 150 cm (106 inch x 59 inch) large plane is integrated for a rear projection. An additional anti-reflective glass pane protects the translucent silver screen behind against scratches made by input devices or other sharp objects. There are several more advantages of the

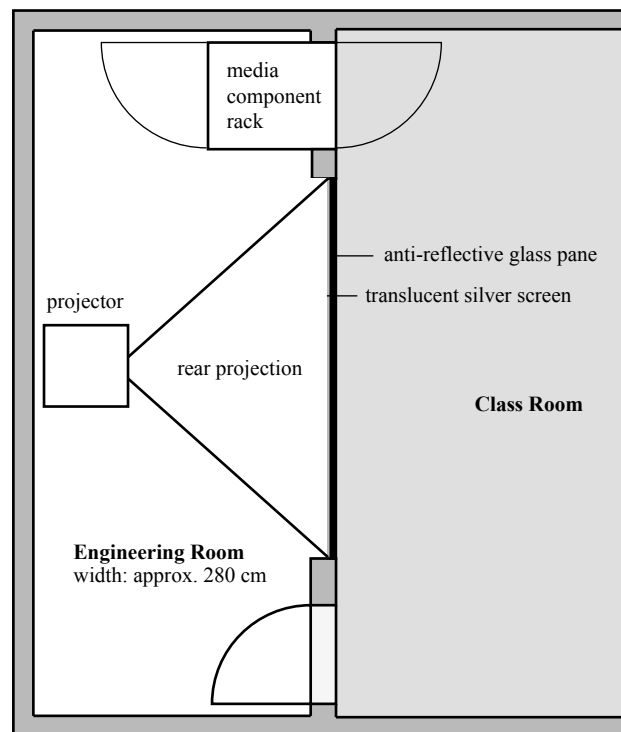


Figure 1. Rear projection placed in our *Lernlabor*. Schematic view of the engineering room and the class room.

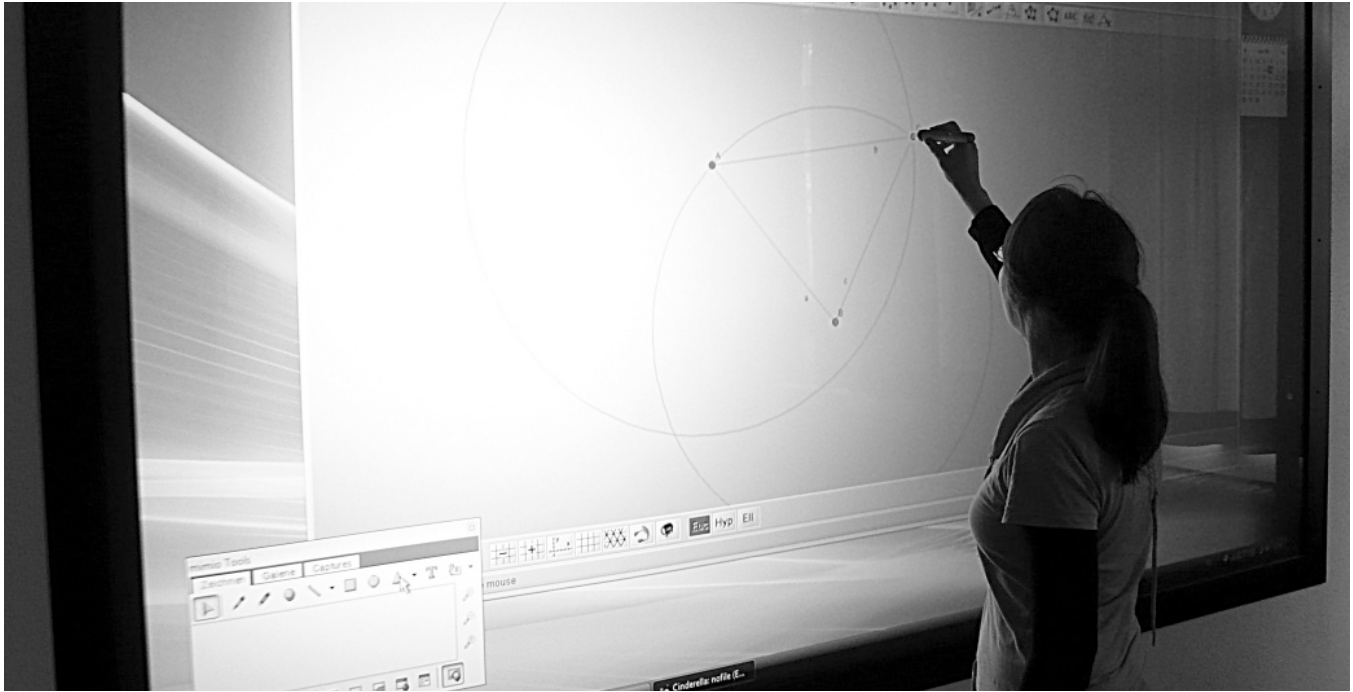


Figure 2. Rear projection placed in our *Lernlabor*. Student works with *Cinderella*.

glass pane e.g. easy cleaning or the non-sensitive surface for interaction. There is also a 19" media component rack integrated into the partition wall. In this case, for teachers it is possible to get in contact with the components, if it is necessary. The cable installation of the components is accessible via the back-door of the rack. So the class room is cable free. Locking the doors of engineering room and media component rack protects the system for operating errors and damage. The load of noise will be reduced to a minimum, because the projector is installed in the closed engineering room.

For projection a *cineo 3+ 1080i* video projector from *projection-design* is used. It provides full high definition resolution of 1920 x 1080 pixels at 60 Hz (Full HD, even better). Because of using the *ultra wide angle 0.75:1* object lens, we only need a projection distance about 210 cm (approx. 83 inch). All video signals from any resource are processed by a *crystalio IP* scaler from *pixel magic*. It provides best quality for up-scaling minor quality video signals. Of course, in a couple of years, several different interactive panels of that size with the given resolution will exist, that provide a similar picture quality. At the moment, they do not. That is why we decided to use a projection device, but with the goal to build a system, that looks and feels like a giant interactive monitor panel. In the next sections more details of functionality and advantages of the systems will be discussed.

2.1 Projection

As mentioned in the introduction part, using a rear projection instead of a projection from the front is one of the major aspects of the system. Any occlusions are avoided. But also, other attributes of the projection are very important. Current IAWs use a system that projects an image with a XGA-resolution (1024 x 768 pixels) and 4:3 aspect ratio. Using a Full HD projection device, the *Lernlabor* system provides improved resolution and 16:9 aspect ratio. Hence, the projection is proportionately wider than standard XGA-resolution. This matches better with the size of known not-interactive white- and/or blackboards. As well, presented content can be distributed more over the width of the projection. That also makes the system easier to use for smaller people, because a larger area of the projection plane is accessible easily. Concerning the large size, it is also possible to use the system for collaborative scenarios with a few students at the same time in front of the IAW, and placing different screens.

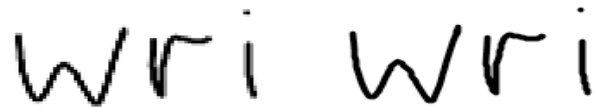


Figure 3. Higher resolution improves quality of handwritten input. Left hand side: XGA resolution. Right hand side: Full HD resolution.

Another crucial aspect is resolution. A higher resolution leads to clearer projected images. This should improve the perception of the presented (more detailed) information. Also, because the image quality advances the analog quality of a blackboard, it should increase user's acceptance of the IAW, even the student's learning motivation. Image quality also depends on (color) contrast. The system provides a contrast ratio up to 7500:1.

1 <http://www.projectiondesign.com/Default.asp?CatID=1509>

2 <http://www.crystalio.com/>

2.2 Interaction

Effective and intuitive interaction is crucial for Interactive Whiteboards. In our system we integrated *mimio interactive*³ from *mimio* for pen based interactions. *mimio* supports only a area of interaction up to the size of 120 cm x 240 cm (approx. 47 inch x 94 inch). In our case, the performance of pen based interaction can be enhanced, using a second *mimio* interactive capture bar. For cascading the receiver, only the units have to be plugged together. Taking this action results a higher accuracy for pen based interactions, especially in the corners and the edge areas. It combines ultrasound and infrared signals to track the position of the pen for high accuracy. The device comes in combination with *mimio Studio*, a software toolkit providing several functionalities for interactive presentations. It provides a host drawing tool and a gallery, to create entire presentations. Any of *mimio Studio*'s drawing and editing tools can be used to markup applications and web pages. All annotations are saved automatically for editing, printing, or exporting later. Also, a lot of interactive tools help to direct the attention of an audience. A spotlight tool allows you to hide the entire screen, except for a region you wish to focus on. A reveal tool can be used to progressively reveal bullet points and information in any application.

In the future we will enhance the *Lernlabor* system with touch and multi touch technologies. Many prototypes of such systems were developed in the latest past. In our opinion, these technologies have a high potential for generating much better interaction possibilities. But also in gesture based interaction our research activities will be forced, especially for educational settings. One point of view could be developing a concept for a complete new input device, which allows the combination of pen based interaction and gesture input, like it is possible with the *Wiimote*. Such a device could make the usability much better and the work with the *Lernlabor* system more effective.

Currently, we are also experimenting with the integration of a *Nintendo Wii*⁴ as a haptic interface into the system. We expect interesting application scenarios for using this device in the area of simulation and training. In future, we want to use the *Wii* devices as innovative input devices for special scenarios in educational settings, e.g. control of learning games or simulations.

As mentioned above, we integrated several other media technologies into the system. However, since our system does not correspond to an integrated consumer product, adequate tools for media control are not provided from the shelf. In our approach, we made sure that control of all components is possible via a dedicated local web server, in our case an *apache tomcat*. By using *java server pages (jsp)* technology it is possible to execute functions written in the programming language *Java*. These *Java* functions offer the control of our media components via rs232 commands or telnet commands via ethernet connection. This provides us with the possibility to develop a media control solution based on web technologies. From an interaction point of view, this allows us to control all media components both, from the dedicated media presenter system (in our case a *Mac Pro*⁵ workstation from *Apple*) and from all connected mobile devices.

In specific, we utilize an *Apple iPod touch*⁶ as a local media control interface for the lab.



Figure 4. Remote control interface on *iPod touch/iPhone* mobile device.

Therefore we developed an interface specialized for the *iPod touch* as the central wireless remote control device of the *Lernlabor* system. The user interface design is geared to the typical *iPod touch/iPhone* look-and-feel. Before starting the development we defined typical use cases for the *Lernlabor* system. Hence, switching between different media presentation with one click is possible (see Figure 4). With regard to an intuitive handling for teachers and students this remote control is very easy to use. No previous technical knowledge is necessary. Teachers, who would like to use the Interactive Whiteboard in our *Lernlabor* have only to do the following: Take the located *iPod touch*, type the "Power ON"-Button in the Media Control application and select the media input by typing the corresponding button. Further, the user have to operate with the standard computer and the software. Therefore a wireless keyboard and an optional mouse is available. So, we reached our goal of user group orientation and high usability for using the *Lernlabor* system for educational settings.

Another goal of our system design was to allow collaborative scenarios in educational settings. In our case, this means that more and more students are equipped with their own laptops or mobile devices. We wanted to support seamless use and interaction with the students' systems. For this, we also integrated a wireless presentation device for receiving video signals from any personal computer or notebook that is located in the laboratory

3 <http://www.mimio.com/products/interactive/>

4 <http://www.nintendo.com/wii/what/>

5 <http://www.apple.com/macpro/>

6 <http://www.apple.com/ipodtouch/>

(see Figure 5). Students can submit their video signal to the system to present their results or ideas they developed on their personal device without having to mess around with video cables. An advanced version of this scenario can be using the optional *mimio Xi wireless upgrade*. This module enables the use of pen based interaction while using personal devices for presentation. For communication with students personal computer there is a kind of dongle included, a 2.4 GHz bi-directional point-to-point wireless interface. All you have to do is plugging this USB connected receiver into student's laptop and the installation for the *mimio Studio* software. In the future, we would like to adapt specific applications from the field of education and training to allow more advanced collaborative scenarios.

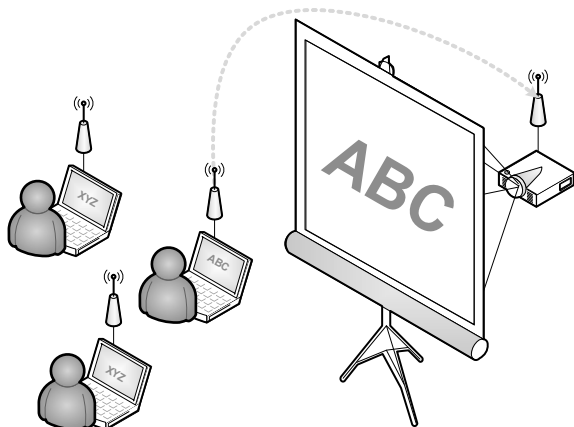


Figure 5. Wireless transmission of video signals from student's notebooks. Schematic view of technical design.

One provided collaborative scenario is the usage of student's notebooks in geography education (see Figure 6). Several students work on their tablet computer. They annotate for example a landscape, given from the teacher. Now, the wireless transmission of signals allows presenting the student's result on the IAW for discussion with the whole class. Also, the teacher and other students can annotate this view on the Interactive Whiteboard.



Figure 6. Collaborative scenario in geography lesson. Wireless transmission of video signals from student's notebooks.

2.3 Integration of Different Media Signals

It is possible to present several kinds of media with help of the *Lernlabor* system. This includes all well known analog media like VHS or other video devices with analog output (sRGB, RGsB, and RGBHV sources). This normally includes also DVD players. Digital video signal sources should be also supported nowadays (DVI, HDMI). Of course, there is also an integrated sound system available, which provides 5.1 surround sound for all media input devices. We wanted to set up a digital signal pipeline, where all analog signals would have been converted to digital signals before further processing. On one hand, this would be quite expensive and on the other, still some technical problems exist with digital signal routing (or it would get even more expensive). For this reason, we decided for a two-track policy. Analog signals are routed with an analog matrix switcher that is connected to the image pre-processor, which has both digital and analog inputs. Digital signals are switched directly at the pre-processor.

Based on this architecture, old analog media like VHS as well as high quality digital signals from a workstation for presentation, the wireless presentation device and a current Blu-Ray player, which provides Full HD 1080p video signals, have been integrated into the system. High resolution visual material like the remarkable nature/wildlife *BBC* series "*Planet Earth*"⁷ have already been released in high definition quality. This material could be used e.g. in biology or geography classes in an illustrative meaning. The usage of video content in lessons gets much easier by working with this system. So, the integration of different media types could get a higher acceptance and usage in educational settings.

3. APPLICATION AND EXPERIENCES

Currently, we are using the Interactive Whiteboard in several classes and seminars for students in different subjects of teacher education and in media-related subjects. First informal evaluations with students and teachers participating in the seminars confirmed that most of the design goals for the HD Interactive Whiteboard were in fact achieved. These include:

- More flexible application and educational settings compared to traditional Interactive Whiteboards due to the higher contrast ratio and the much lower interference with environment lighting, thus reducing need for darkening and therefore for adapting the environment.
- More intuitive use based on the rear projection that solves the problem of obscuring the projection and having to move around those areas of the screen for interaction. In addition, the higher resolution and the better response to pen based interaction also clearly increased usability and acceptance of the system.
- The provided interaction technologies, especially the wireless transmission of video signals, allowed for new and more flexible settings in the classroom with integration of students' laptops.

7 <http://www.bbc.co.uk/sn/tvradio/programmes/planetearth/>

- Central remote control by a mobile device (in our case a *iPod touch*) allows controlling the needed features by defined use cases with only one click. High acceptance by the users was achieved, because no technical knowledge is needed.

Using IAWs for mathematics has already been established. In April 2008, we started a seminar dealing with the “application of personal computers to math education”. In this seminar we are concerned with “Interactive Geometry Software” (IGS) (in this case: *Cinderella*⁸ [4]) but also spreadsheets, HTML, and interactive worksheets.

A good example is the following scenario: We used PDF-documents as worksheets, where variation tasks of a triangle were given. Sketches of the construction were part of the worksheet. Only one task was presented on the screen using the reveal tool in *mimio Studio*. In annotation mode, students should draw in their ideas concerning changes of specific intersections while modifying the construction. After doing so, the problem should be solved directly using an IGS (*Cinderella*). Afterwards, the IGS construction and the hand drawn sketches were presented next to each other. Doing so, the drawn assumption could be checked against the IGS results. This session gave the impression, that students highly accept our next-generation IAW. The students dealt with the system in an intuitive and open-minded manner.

4. SUMMARY AND CONCLUSIONS

In this paper we presented the design of an HD Interactive Whiteboard based on rear projection technology. We discussed the potential of HD components in the class room and highlighted various advantages. With our HD Interactive Whiteboard system with rear projection we were able to proof that high-end video components are getting within reach nowadays, both in terms of availability of suitable components and in terms of price. Especially the higher degree of resolution and contrast as well as the availability of new interaction devices may provide the necessary increase of quality to achieve higher acceptance of such systems and, in future, a higher distribution in the class room. Much bigger projection and interaction area than current IAWs allows new possibilities for different collaborative scenarios. It is clear that the HD rear projection solution might be too complex to make their way into schools. However, HD LCD systems are also in development and we expect corresponding large flat panel technologies in the near future. Today HD rear projection technology is almost ready for being used in a wider degree in educational settings.

Indeed, there are some tasks we have to solve in future. We have to get to know, how to integrate IAWs better into teaching scenarios and how we have to change standard control tasks of software for better usability on such a big wall. For example it is difficult for small persons to reach the closing buttons in the upper corners of the projection pane. To interact with the whole system users have to move a few steps to get from one side to the other side of the projection surface. Switching between different tools must be optimized. Also, there are additional requirements for the use of *mimio studio* software depending on the size of the IAWs.

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