# Experimental Tools for a Multimedia-Supported Interactive Lecture

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**Abstract:** The experimental tools for multimedia-supported interactive lecture presented in this paper have as their main goal to improve the quality of the presence lecture by using state-of-the-art presentation tools and wireless infrastructure communication techniques. Thus, the lecture is enriched with multimedia and computer-supported interaction between students and teacher, in order to improve their motivation and efficiency. Quizzes and immediate feedback to the lecturer through a server give the students the chance to adapt the lecture to their learning capabilities and to increase their attention and motivation. They are also enabled to give additional feedback via messages to the teacher. The results of the evaluation of the interactive lecture will show the success of our approach.

## 1 Introduction

The University of Hannover is engaged in a variety of projects with the objective to introduce new multimedia and ubiquitous technologies into the everyday university environment. We supply every student of selected curricula with a wirelessly connected notebook computer. In addition, we have built the necessary infrastructure and corresponding services to support teachers and students. The communication infrastructure is composed of a campus-wide Wireless LAN (WLAN, IEEE 802.11) and, for special applications, of Bluetooth islands [MSP00].

The UBICAMPUS project is one of 25 projects supported by the German Ministry of Research and Education, Neue Medien in der Bildung. Its goal is the development and introduction of new mobile and multimedia-based technologies for on-campus learning. A notebook university is, according to the call for projects, a new form of university organization based on the extensive usage of mobile computers and wireless communication networks. Networked laptop computers are the standard working equipment for students as well as for teachers. UBICAMPUS developed four scenarios to demonstrate typical situations representative for interactive and laptop-based learning. The four scenarios are (1) the interactive lecture, (2) the group-selective lecture, (3) the notebook seminar and (4) the mobile project group. All four scenarios have been implemented, integrated into the normal curriculum and finally evaluated by participating teachers and students.

Unlike in other notebook projects, we think that it is not sufficient to equip students with notebooks and internet access and leave them alone. Notebooks in the auditorium become useful only if they are tightly integrated into the communication patterns typical for a lecture. This requires a learning process from students as well as from teachers. Of course, this doesn't preclude the usage of the notebooks for other purposes like information retrieval, inter-student communication or text processing.

In this paper we will discuss the didactical concept and the tools we have developed or adapted for the Interactive Lecture, report on our experience with the first run of the lecture in February 2003 and give some outlook on future plans.

## 2 The UbiCampus Project

UbiCampus introduces ubiquitous technologies into the university environment. Ubiquitous technologies are ideal instruments to support the goals of a notebook university for the following reasons: (1) They offer access (anytime, anywhere) to the multimedia course material. (2) They use contexts to guide the users. (3) They allow the creation of ad-hoc communities, which are a typical form of interaction in teaching and learning environments. (4) They create dependable information structures in a highly mobile and partially volatile environment.

Four scenarios have been realised in the UbiCampus project:

*Scenario 1: Interactive Lecture*

The objective of the interactive lecture is to improve the quality of teaching and to better transfer knowledge from the teacher to his students. To achieve this goal the lecture is enriched with multimedia and interactive elements. The students are equipped with multimedia-capable wirelessly-connected devices (e.g. WLAN notebooks). The main differences between a conventional and an interactive lecture are:

- Students are equipped with wireless notebooks.
- The course textbook is displayed on the notebooks. It is enriched with multimedia elements (animations, video, annotations…).
- Online quizzes with automatic corrections and statistical result presentations are given during the lecture.
- The students can interact with the teacher through anonymous electronic messages.
- The students can control the pace of the lecture.

Other than that, the interactive lecture is a regular class with physically present teachers and students.

*Scenario 2: Group-Selective Lecture*

The group-selective lecture is an interactive lecture which addresses different target groups of students. As an example, the study of basics in physics is part of many different university major subjects. Students of engineering, medical sciences, biological

sciences and others have to take common classes in physics. These students have different backgrounds and goals. The group-selective lecture allows the combination of different student groups in a single auditorium and at the same time the optimisation of the class material for the different target groups.

*Scenario 3: Notebook Seminar*

The notebook seminar [Job03] assumes that students learn better and more effectively through an action-based self learning approach. Basic methods of scientific work are integrated in the learning process and supported through the use of new media. A small group of students (15 to 20) has to solve complex tasks using the given information infrastructure (e.g. databases, digital libraries, WWW) intensively.

*Scenario 4: Mobile Project Group*

Similar to the Notebook Seminar scenario the students have to solve one very complex task, as a group. In contrast to the notebook seminar the task is larger (one task per semester) and the group is smaller (4 to 5 people in a group). The main objectives of the mobile project group are similar to the notebooks seminar. Further objectives are the establishment of a (social) process through monitoring functions. Thus a training of the social skills of the participants can be achieved.


# 3 Interactive Lecture Didactical Concept

By Interactive Lecture we mean a campus-based activity with physically present teacher and students. Although in certain cases it is certainly helpful to include remote students into a local event (or let a remote lecturer talk to local or even distributed students) we think that this should rather be the exception. The direct contact between students and teacher is extremely advantageous and it should not be sacrificed unless absolutely necessary, in special situations.

Maybe it is not only the authors' experience that a typical lecture is a 1:many situation, i.e. 1 teaching:many sleeping. We think that students should spend their time in the auditorium more effectively. They will memorize the lecture content easier and have at the same time more fun if they learn more actively. We observe 9 communication patterns in an interactive lecture which should be supported by notebooks:

1. Distribution of lecture notes: The students should be able to download the transparencies (or powerpoints) well in advance before they go to the lecture hall in order to prepare the lecture (We talk here about the ideal student!)

2. Presentation: The lecturer presents and explains the powerpoints.

3. For most presentations it is very helpful to have a second projection screen available. It can be used e.g. to keep the table of contents visible at all times. Also, certain complex pictures with overview character can be displayed. In the case of computer

science lectures, a computer desktop is necessary for direct demonstrations, simulations or internet access.

4. Demonstrations shown by the lecturer are helpful but learning by own example is even more desirable. So the students must have access to the internet or to a server to run their own test programs or simulators on the spot.

5. Annotation lecturer: A non-stop presentation of 50 powerpoints is very tiring. Especially complex pictures should be developed step by step using the powerpoint animation mode. Even more lively are handwritten annotations made by the lecturer in response to the questions asked by the students. We had to find a way to make annotations on the fly and to distribute them to the students.

6. Annotation student: Very important for a permanent learning experience are annotations made by students, like highlighting, underlining or writing short comments into the powerpoints. So we need a way to merge (1) the original powerpoint, (2) the teacher's and (3) the student's annotations.

7. Students in a large auditorium usually fear to ask questions. We have implemented a messaging mechanism to ask written questions. It is quiet but not anonymous to prevent misuse.

8. It is helpful for the teacher to provoke reactions from the students from time to time by asking questions in order to get an impression about the proper acceptance of his explanations. Direct questions to single students are embarrassing. Also, they don't give a proper impression about the knowledge of the whole auditorium. We have implemented a test-question mechanism allowing the teacher to ask prepared multiple-choice questions and evaluate the results statistically after a few minutes.

9. Finally, we wanted to experiment with some anonymous feedback from the students to the teacher. The students could move a slider from "good" to "bad" or from "slower" to "faster". The teacher sees the aggregated results and can adapt his teaching style accordingly. Since "good" and "bad" are not really well defined we have decided in favour of a speed control mechanism, also since an unanimous cry to slow down can be followed easier by the lecturer, than a quest to "improve" the lecture.

The above 9 patterns are a subset of even more complicated possibilities. They were regarded as being sufficient for our first run. One concern which proved to be justified later was that we might overload the students as well as the teacher with the handling of all these new communication channels and at the same time follows the lecture's content. Since this is especially a problem for the teacher who has to handle all the tools in parallel to his presentation, we have built a special multi-media desk equipped with three screens and which helps him to manage the complexity. One obvious effect is a forced slow-down leading to increased depth and reduced width of the lecture.

The following chapters will discuss the technical set-up of our teaching scenario and the experience we made from the students' and the teacher's point of view.
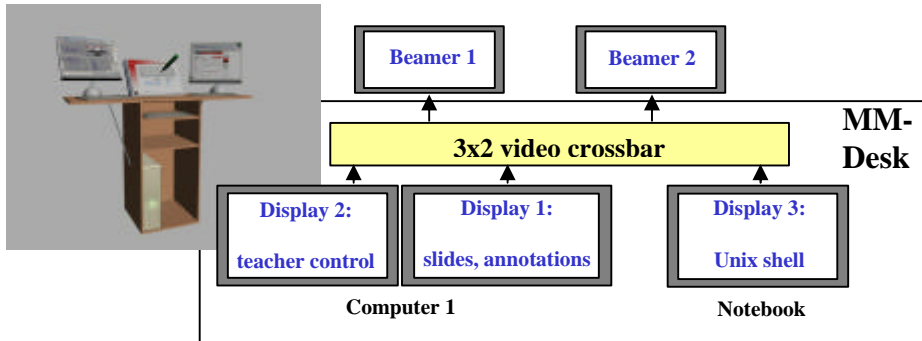
# 4 The Pilot Lecture

## 4.1 The Multimedia Desk



Fig. 1:    The Multimedia Desk.

According to our goals and learning from the experience of other multimedia oriented teaching approaches [HSKV01], [WEGL00] we have built the multimedia desk, as an important component of our multimedia infrastructure (see Fig. 1). Its components are enclosed in a wood housing and provide all the technical means a lecturer needs during a lecture, arranged for convenience in a control panel.

Our scenario implies that the lecturer will have two desktops on a main PC. The primary desktop (Display 1) is related to a touch-sensitive display and will usually be shown through a beamer in front of the students, under the control of the Smart software for on-the-spot annotations. The secondary desktop (Display 2) is private and used to prepare the next step of the lecture. For demonstrations, the lecturer can use a laptop, whose display (Display 3) is also shown to the audience.

Both computers have Ethernet and WLAN connectivity. The main PC has also a Bluetooth adapter and a few USB ports. This way we can achieve maximal connectivity, almost anywhere and to anything: all kinds of data networks, storage as well as pointing devices. The PC features a dual-head graphic card. We have connected two displays (Display 1 & 2) to this card. The video outputs from the PC and laptop are mixed through a video-switch, which serves as input for the two beamers in the lecture hall.

This multimedia desk proved to be extremely useful during presentations, being used not only in this context, but broader in other lectures and meetings. Its functionality proved to be reach, stable and easy to use, although some elements of design will be refined.

## 4.2 IVES

We embrace the presence-learning paradigm, which requires the students to take active part in the lectures. Our target is to make the laptops a consistent part of the teaching process, by using them to support extensive interactivity between lecturer and students.

We attempt to augment the traditional presence-learning process with computer-based multimedia and interactivity.

As a central element of the teaching process, the extended interactivity is supported through the IVES system (Interaktives Vorlesungs-Evaluierungssystem). IVES is a web application within the Apache Tomcat Application Server [Tomcat]. A web application consists of servlets, software that behaves like web services, but whose user interfaces appear only in browsers. Therefore we simplify the deployment process, because all a user must have in order to use IVES is a browser. On the server side, servlets are almost as powerful as any program, having access to resources like files and databases. We use this feature to store the management information related to IVES in a MySQL database.

The main functions of IVES are related to the visualization and manipulation of questions, answers, quality parameters, messages and users by entities having one of the following roles: lecturers, students and administrators.

***Lecturer Role -*** An entity having the role lecturer can create and adapt question sets, either on-the-spot or (preferably) before the lecture. The questionnaires can contain questions of the types: (1) yes / no questions, (2) questions with one-word answer and (3) multiple-choice questions. All these types of questions can be combined creatively to test many types of knowledge. During the lecture, question sets can be made public in order to be answered by the students. As soon as they send back their answers, the lecturer can access a real-time statistical evaluation of the results.
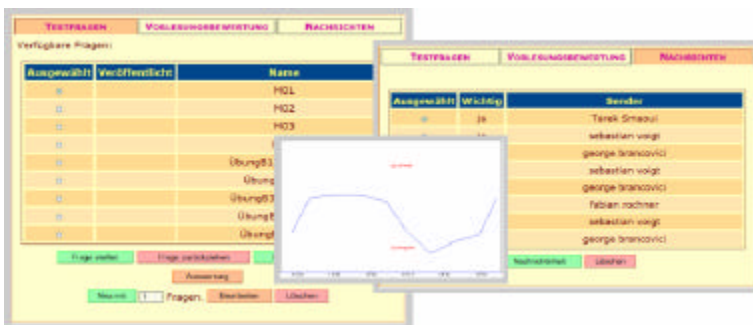


Fig. 2:     The lecturer's view with quizzes and feedback.

The lecturer has the chance to change the future course of the lecture dynamically, upon how the students evaluate through IVES different quality parameters of the lecture (like the speed of the presentation). Our system can serve as a silent-messaging platform from the students to the professors.

***Student Role -*** A student can first see a list of public and not-yet-answered questions. She can select a question, display and answer it. Besides evaluating the knowledge the students gather during the lecture, IVES allows the audience to send feedback. The students can not only assess quality parameters of the lecture, but also avoid the stress of asking direct questions in the lecture, by writing e-messages and sending them directly to the lecturer.

Fig. 3:     The students view with quizzes, messages and quality control.

***Administrator Role -*** There is a third role, the administrator, whose member entities can manage the user accounts in the system, which is necessary for the large number of users we have had.

We were very successful while using IVES in the real lecture, which is itself a proof of its appropriate design. It's worth mentioning that the feedback from our audience was extremely good. The questionnaires were made public every twenty minutes, but the students wanted more of them. Nevertheless, we intend to further develop IVES and make the user interface even more accessible and intuitive. This can be extremely helpful when the student must work with several simultaneously opened windows. In such a situation, an interface designed as a quick-access toolbar, with three areas corresponding to the present sections of IVES and pop-ups for additional input or output would make IVES even easier to use.

## 4.3 The Annotations

An important part of our strategy is the annotation of the slides from the presentation. The lecturer and the students access a fresh copy of the slides. This has intentionally-empty areas to be filled in by the lecturer in front of the students, using the touch-sensitive display and the Smart software. The students can make their own regular annotations. When the lecture ends, the lecturer distributes a copy of its modified slides to the students. Now they can merge it with their own annotated copy using standard PowerPoint XP functions. The individual result for each student consists of slides which contain her annotations and those made by the lecturer. For the success of the annotations it is very important how the initial slides are prepared. If this is done properly and the empty spaces are placed in strategic positions, then the students will be more attracted and will pay more attention to the lecture. As a possible extension of the current system, the annotations made by the lecturer could be automatically mirrored in the presentations that the students already have.

## 4.4 Smart Display and Smart Software

We use software and hardware from Smart Technologies Inc. ([www.smarttech.com](http://www.smarttech.com)). This hardware consists of a touch-sensitive display and a special pen that is used to write

on it. The pen can be configured through hardware buttons on top of the display. The lecturer uses it to make annotations. The Smart software keeps track of the objects drawn on the screen and makes them available to applications. The entire content of this display is usually beamed in front of the students. In our scenario, all annotations made on the display are sent to the Smart software which saves them in PowerPoint as objects.

# 5 Evaluation

## 5.1 The Lecturers' View

The interactive lecture is a challenge for the teacher and the students, as a new form of presentation of the course material. The teacher needs some training to get acquainted with the new equipment. He has to give his lecture and also control three displays, simultaneously. The effort to prepare and present an interactive lecture is much higher than for a conventional one. The benefit gained from this extra work is more attention and concentration from the students. Especially the interactive parts of the lecture (quizzes and feedback) draw the full attention of all participants and the students commented these aspects very positively.
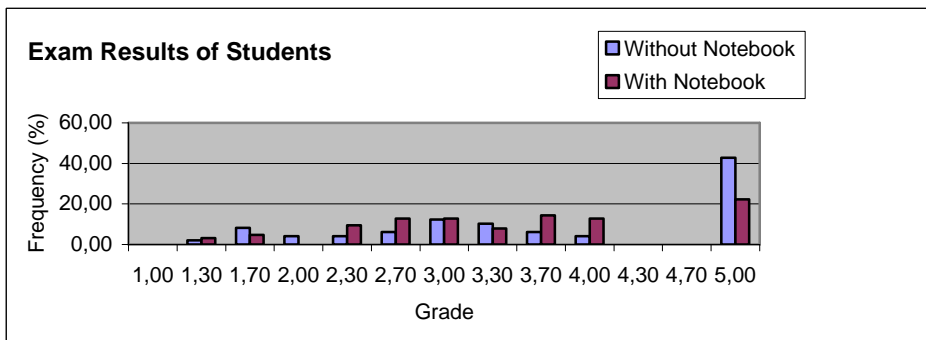


Fig. 4:    Evaluation of student's exam results

The pilot lecture was given for 63 students with notebooks and 49 students without. The diagram shows the exam results for the both groups of students. The best grade a student can get is 1.00, the worst grade for passing the lecture is 4.00. The grade 5.00 is for the students who failed. Only 22% of the students with notebooks have failed compare to about 43% students without notebooks. The average grade for the students with notebook is 3.50 compared to 3.74 for those without notebooks.

In summary, the benefits of the interactive lecture make the higher effort worthwhile. The students show more interest and better concentration. The lecture is more attractive and the exam results are better. Problems might occur when this form of lecture is used in non technical studies since basic knowledge of modern software tools and infrastructure is required on behalf of the teachers as well as of the students.

## 5.2 The Students' View

Most students expect increased benefits when notebooks are used in their professional education. The main reasons not to take part were monetary restrictions: some students simply can not afford a notebook (even at half price). This is a problem to be solved in the future (hardware gets cheaper, industrial sponsor programs, leasing models,…). The lecture *Einführung Betriebssysteme* (*Introduction to Operating Systems*) was given as a conventional lecture in the winter semester 2001/2002 (WS 01/02) and as an interactive lecture (with notebooks) in the winter semester 2002/2003 (WS 02/03). Among others, the students were asked 8 questions and the answers were grades from one (best) to six (worst):

Q1: How well was the teacher prepared?
Q2: How well could the teacher be understood?
Q3: How readable was the presentation?
Q4: How well were the media used?
Q5: How well was the course material arranged?
Q6: How well was the course material presented?
Q7: How well were the student's questions answered?
Q8: How do you rate the course material?

In WS 01/02 there were 85 students, in WS 02/03 there were 77 students who filled out the questionnaires.
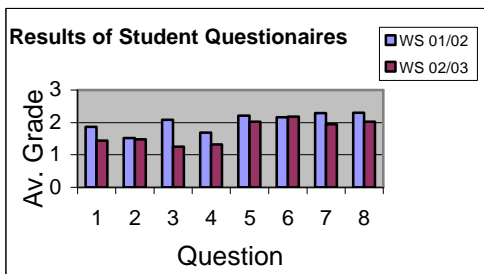


The average grades were in most cases better for the interactive lecture. It seems that question 6 (with a slightly worse rating than in the year before) indicates that it has become a challenge for the teacher to lecture adequately while managing his multimedia controls. Since the lecture was given for the first time there is still space for improvement.

Fig. 5:     Evaluation of questionnaires

In summary, the students were very pleased with both, the support for buying a notebook and the interactive lecture itself. In our mind, the notebook will replace the paper and pencil approach for classes in the near future for many students. It is probably easier for students in technical sciences right now, but with an improvement in usability and services, this will also be the case for other sciences in the near future. In the near future, the tablet computer could be a better solution, although now it is still too expensive.


# 6 Conclusion and Future Plans

We have reported in this paper about the technical infrastructure for a notebook-based interactive lecture and our experience with the actual running of the experiment in a real

life lecture situation. The results are encouraging in terms of student motivation and examination results.

On the other hand we acknowledge also some drawbacks and impediments:

- We have achieved coverage of about 50% of the students with notebooks, based on the fact that we were able to sponsor the procurement of the notebooks. This will not be possible any more after the pilot project has ended. However, we expect that notebooks will be less expensive in the near future and that they will become standard work equipment for every student.
- The complexity of running a multimedia-supported interactive notebook lecture is quite high for students as well as for the teacher. As a matter of fact, we think that an even larger complexity cannot be handled any more and would be counterproductive.
- The effort to prepare the course material for multimedia-supported lectures is already quite high. It is even higher for interactive lectures. The authors see no realistic possibility to extend this type of lecture to the whole coursework of the university. The preparation of the material was possible in this case only since additional project-funded manpower was available.

Nevertheless we are planning to build on the positive experience and provide some extensions to the present system. We are working on simpler to use user interfaces for the interaction between individuals or between the teacher and a group. These so-called InfoSpaces [WMB03], [BMV03] will provide a more intuitive way to communicate in wireless ad-hoc environments.

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