

THE INTERACTIVE LECTURE – AN INTEGRATED MULTIMEDIA-SUPPORTED TEACHING EXPERIMENT

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Key words: *Multimedia Teaching, Interactive Classroom, Notebook University*

Abstract:

The interactive lecture presented in this paper has as its main goal to improve the quality of a presence lecture by using state-of-the-art presentation tools and wireless infrastructure communication technology. Thus, the lecture is enriched with multimedia and electronic interaction between students and teacher to both improve motivation and efficiency. In this article we will show how technology can be used to add value to teaching classes. Quizzes and wireless connections to a server are used to give the students a chance for immediate control of their learning success and for the increase of their attention and motivation. They are also enabled to give feedback to the teacher on their ability to understand the lessons being taught. The results of the evaluation of the interactive lecture will show the success of the 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 are planning to supply every student of selected curricula with a wirelessly connected notebook computer. In addition, there will be the necessary infrastructure and corresponding services to support teachers and students. In the future, terminal devices will not only be laptops and notebooks but also handhelds like PDAs, enhanced mobile phones and stationary devices like large size wall-mounted displays. The communication infrastructure provided is a campus-wide Wireless LAN (WLAN, IEEE 802.11) and, for special applications, Bluetooth islands [1].

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 multi-media-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. The two universities in Hannover participating in the UBICAMPUS project, Universität Hannover (UH) and Medizinische Hochschule Hannover (MHH), offer an excellent environment for the project. Large parts of the campus area have been covered with wireless communication access points.

UBICAMPUS develops 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 4 scenarios have been implemented, integrated into the normal curriculum and finally evaluated by participating teachers and students.

Students of computer science and other selected disciplines are equipped with cost-reduced state-of-the-art notebooks with WLAN connection. During the project the average price of 1500 € for each notebook is further reduced through special grants in order to allow the majority of the students to participate.

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 is a learning process for students as well as for 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 briefly describe all four subprojects of UBICAMPUS, 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

The project to realize a Notebook University at Hannover is called UbiCampus. The name combines the word ubiquitous which stands for "ubiquitous computing" and the word campus as a synonym for the university campus. Ubiquitous technologies are ideal instruments to support the goals of a notebook university for the following reasons:

- They offer access (anytime, anywhere) to the multimedia course material.
- They use contexts to guide the users.
- They allow the creation of ad-hoc communities, which are a typical form of interaction in teaching and learning environments.
- They create dependable information structures in a highly mobile and partially volatile environment.

Using the existing infrastructure (LAN, WLAN), the mobility through WLAN connected notebooks, and the experiences in multimedia teaching, the main goals of the UbiCampus project are:

- the definition, implementation, and test of typical scenarios of a notebook university,
- the realisation and the further extension of the necessary service and communication infrastructure, and
- the evaluation of the scenarios in selected pilot lectures.

To achieve these goals, four scenarios are realised through 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 has to be enriched with multimedia and interactive elements. The students have to be 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.

Others 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 [2] 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. Through their WLAN notebook they are connected to a tutor who can help them with their problems. Using electronic communication forms like chat, email, or video conferencing allows to independent of time and space. After the students have solved their task they have to show their ability to document the results. The documentations should also be enriched with multimedia elements like PowerPoint slides, animations and video clips.

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 an exception. The direct contact between students and teacher is extremely advantageous and 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 more easily 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 making their own experience 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: Even more important for a permanent learning experience are annotations made by the 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 are scared 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 after a few minutes statistically.
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 by handling all these new communication channels and at the same time follow the lecture's content. Since this is a problem especially 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 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 Pilot lecture

4.1 The Multimedia Desk

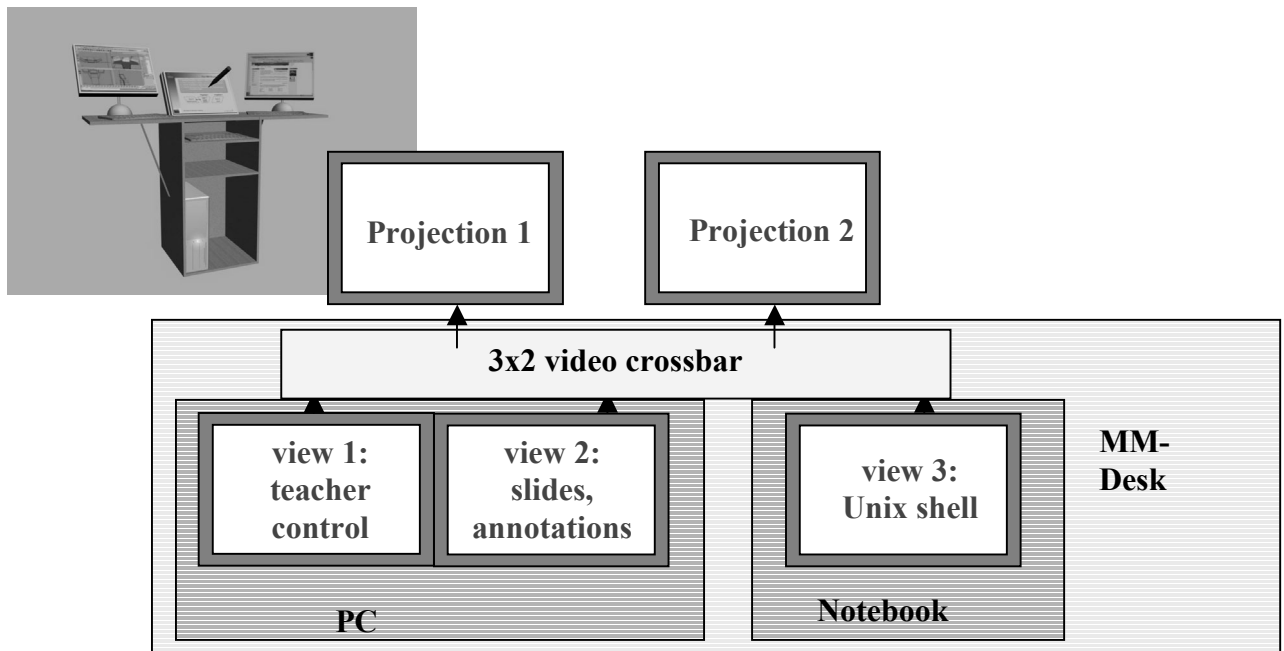


Fig. 1: Multimedia Desk

According to our goals and learning from the experience of other multimedia oriented teaching approaches [5], [6] we have built our so called multimedia desk as a central component of our multimedia infrastructure (compare Fig. 1:). This custom made lecturer's desk is enclosed in a wood housing and provides all the technical means a lecturer would need to use during the lecture, as a control panel.

At its heart there is a PC which has up to two displays attached to it, as well as full communication connectivity (Ethernet, WLAN, Bluetooth). To the special dual-head graphic card inside the PC connect two displays: a regular and a touch-sensitive one. A second portable computer can have its output mixed together with the above mentioned displays, while everything is redirected through a video-switch towards each of the two projectors available in the lecture hall.

The metaphor behind this setting requires the lecturer to have at least two easy-to-manage desktops, a public and a private one, each corresponding to a physical display. The latter display is used to prepare the information; its content is not shown to the students, while the former one is used to display and control the slides to be projected to the students. The public display is touch-sensitive and can therefore be used in conjunction with the Smart software to make annotations and other additions directly into PowerPoint, in front of the students. The portable computer provides, when necessary, a third display to be used for practical demonstrations of the theoretical ideas shown on the main computer. In other words, usually the public display of the main computer and the one of the portable computer are shown to the audience.

Both computers have Ethernet and wireless LAN connectivity. Additionally, the main PC features a Bluetooth adapter for short-range communication, as well as a few USB ports, for connecting devices like memory sticks or remote presentation controls.

This multimedia desk proved to be extremely useful during presentations, being used not only in this context, but broader in other lectures and meetings. While the housing could benefit from some extra refinement in a future version, all of the built-in functionality proved to be stable, useful and easy-to-use.

4.2 IVES

As we have previously stated, our scenario relies on the presence-learning paradigm. Therefore we expect the students to come into the lecture hall and take actively part in the presentation. The novelty we introduced along with the notebooks was that we managed to make them a consistent part of the teaching process. We go beyond using notebooks only to store or process documents in the traditional fashion and promote extended interactivity between the lecturer and its students. In our nomenclature, we want to augment the traditional presence-learning process towards computer-supported multimedia and interactivity. As a central interest of our work, the interactivity is primarily done through the IVES system (Interaktives Vorlesungs-Evaluierungssystem which translates to Interactive Classroom Evaluation System). IVES is implemented as a suite of web applications that run as servlets within the Apache Tomcat Web Application Server [3]. The servlets behave somehow like web services: they use the requests received from the client in order to initiate some processing and provide the results back to the client. The main difference is that they always receive these requests from the client's web browser and return the results back to it, in HTML. The advantage of this solution is that the entire interface runs in a regular web browser, reducing the client deployment process to zero. Additionally, servlets have access to all resources available from the web server, both to local and remote ones, like files and databases. We use such features behind the curtains in order to store and retrieve information from a MySQL database.

Tomcat runs on a dedicated server with fast network connection and it is fine-tuned for optimal performance and reliability, in order to support the usually large number of students in a lecture.

The main functions of IVES consist of allowing the lecturer to publish questions to be answered by students and of allowing them to directly influence the lecture's future and silently ask questions about it. In turn, the lecturer is supposed to react to the feedback received from students. The users of IVES can have their accounts managed by administrators.

Therefore we differentiate between three types of users (roles): lecturers, students and administrators.

Lecturer Role

The lecture role has the possibility to create question sets (quizzes) in advance, usually before the lecture. These quizzes can be later modified or deleted as needed. We provide support for several types of questions depending on their types of answer, all having the possibility to contain HTML code in their bodies, which makes them more explicit and appealing to the students. There are three types: (1) yes / no questions, (2) questions with a word as an answer and finally and most importantly, (3) multiple-choice questions. The yes / no questions could also be used for non lecture relevant purposes such as voting for or against a proposal of the teacher. By using combinations of these types of questions, one can test all kinds of knowledge. Once the sets of questions are defined, the lecturer can make them visible to the audience, by publishing them for a given period of time. While the students return their answers to the quizzes, the lecturer can see a real-time evaluation of them.

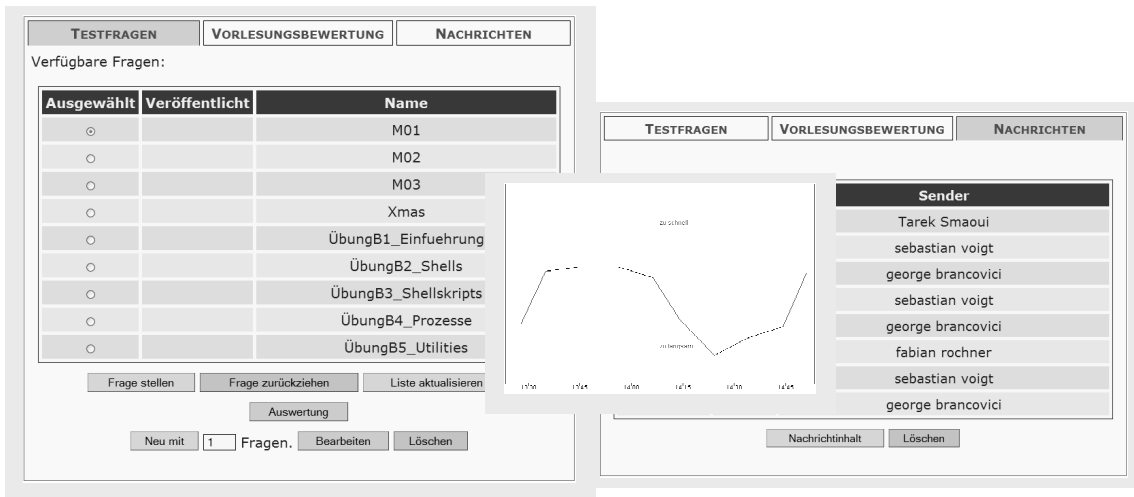


Fig. 2: Teacher's control view for quizzes and feedback information

Another important function of IVES gives the lecturer the chance to see, again in real-time, how the students evaluate the past and present course of the lecture, in order to change its future course. We use the speed of the presentation as a measure of how the students evaluate the quality of the lecture. At last, IVES displays the silent messages from users as soon as they arrive, in order of their priority, since the student can specify whether his message is important (urgent) or not.

Student Role

At any given time, IVES displays a list of all un-answered questions that have been made public by the lecturer, to each student. One can choose a question and display it, in order to answer to it.

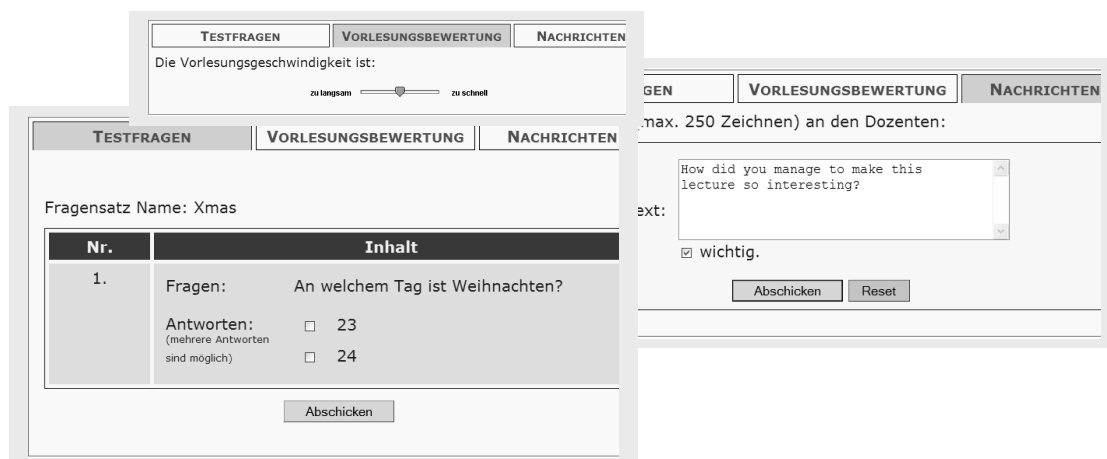


Fig. 3: Student feedback for the teacher through quizzes, messages and sliders

Each student can evaluate the lecture in real-time, influencing its future course. Also, some students find it difficult and stressful to ask questions during the lecture and in front of the audience. We provide in IVES another function that allows them to write electronic messages and silently send them to the lecturer. This means that they do not appear on the public display, although they are not anonymous in order to avoid misuse.

Administrator Role

Since we have many users in our system, we introduce a third role called administrator, who has the power to manage the user accounts, which includes creating and deleting them, as well

as changing some of their parameters. We heavily used IVES in the real interactive lecture environment without encountering any technical problems. Therefore we consider that the design of IVES proved to be quite adequate. The reactions we have received from our audience were more than positive in regard to IVES. The students have been quite interested in our quizzes, which in average were published every twenty minutes, asking for more. Additionally, the silent messaging function was heavily used too.

As for the future development of IVES, we intend to make a redesign of the entire interface, in order to make it more accessible and intuitive for the user. We considered the case when the student has already many opened windows and cannot concentrate all the time on IVES. The new interface could be organized as a quick access bar, with three sections. The first section will display an alarm every time a new quiz is available, giving instant access to it. The central section will contain a slider for the student to evaluate the lecture. The last section will allow the student to popup a window to write a silent electronic message to the lecturer.

4.3 The Annotations

The annotations to the lecture's slides are a very important part of our strategy. These slides are publicly available in the web and can also be reached from a link provided in IVES. We provide initially both the lecturer and the students with a "vanilla" version of the slides, containing specifically introduced empty areas to be filled in at lecture time by the lecturer. The lecturer makes its annotations in front of the students by using the touch-sensitive Smart display, which automatically saves them in the PowerPoint slides. Simultaneously, the students make their own personal annotations during the lecture, using standard PowerPoint tools.

At the end of the lecture, the version of the slides annotated by the lecturer is uploaded to the same web location where the original "vanilla" slides reside. All the students download this new version of the slides and merge it with their own annotated version, by using the PowerPoint merge function (Office XP version). The resulting slides will contain, for each student, the annotations from both the lecturer and the students himself.

The conclusion we have drawn is that the way the original "vanilla" slides are prepared is extremely important for the success of the entire annotations' metaphor. If properly done, the annotation process can attract the attention of the students and make the entire lecture more appealing and lively.

4.4 Smart Display and Smart Software

The software and hardware we use is from Smart Technologies Inc. (www.smarttech.com). The public display being projected to the students features a touch-sensitive surface. With the help of a special pen, one can write directly on the screen. Some parameters like color and shape of the pen can be controlled by using several hardware buttons on top of the display. In this way the lecturer can make annotations that are automatically displayed. A Smart software layer that complements the display device itself keeps a track of the objects drawn on the screen and makes them available to different applications running on the computer. The Smart display device has its input connected to the second output of the PC-graphic card, while information about what is written on it is sent back to the computer via an USB connection.

In our scenario, everything that is written on the display is sent to the Smart software which automatically saves it as objects in PowerPoint.

5 Evaluation

5.1 The Lecturers' View

The interactive lecture is also a challenge for the teacher and the students. It is a new form of presentation of the course material. The teacher needs some training to get acquainted with the new equipment. At the same time he has to give his lecture and control three displays. As discussed above, two of the displays are projected onto large screens. One shows the multimedia lecture, the other is for exercises and interaction. The third display is private to the teacher, it is used as help desktop for control and preview tasks. Also the students messages to the teacher are displayed on this screen. The effort to prepare and present an interactive lecture is much higher than to prepare a conventional one.

The benefit of this extra work is a better attention and concentration of the students.

Especially the interactive parts of the lecture (quizzes and feedback) draws the full attention of all participants, and the students commented these parts very positively.

The pilot lecture was given for 63 students with and 49 students without notebooks. The diagram shows the exam results for both student groups. The best grade a student can earn 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 the students without notebooks.

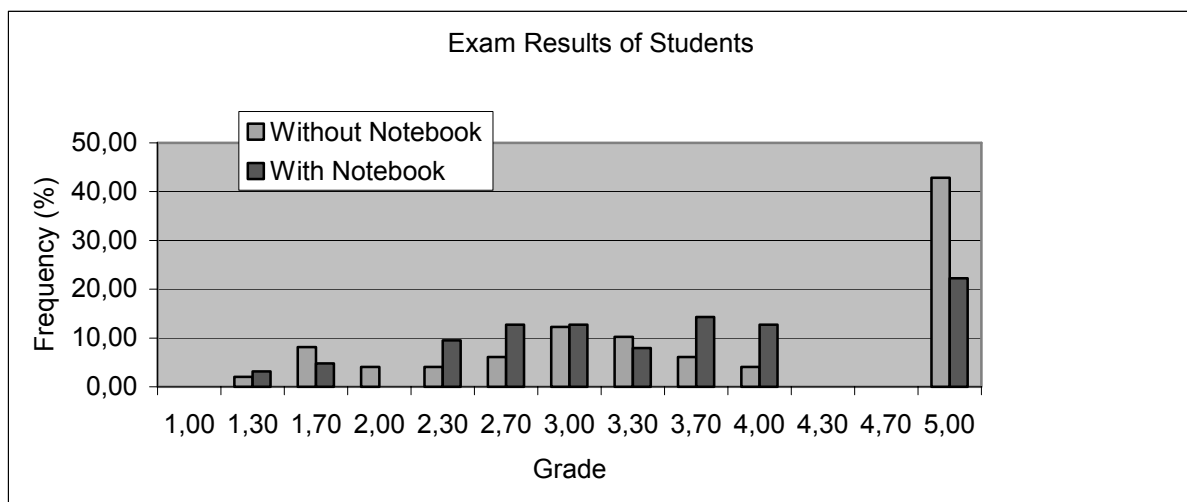


Fig. 4: Evaluation of student's exam results

In summary, the benefits of the interactive lecture are worthwhile the higher effort. 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 in modern software tools and infrastructure is required from teachers as well as students.

5.2 The Students' View

Every first semester student of computer science at the University of Hannover could apply to participate in the pilot scenario interactive lecture. An allowance of 750 Euro to buy a notebook was offered to all participants. At a total cost of approx. 1500 Euro for a state-of-the-art notebook, the project and the university sponsored half of the cost. In return we requested students to actively participate in the lecture and the related examination. Also, we expect from participating students to earn at least 50% of the possible credit points during the first study year. 65 out of 120 students decided to buy a sponsored notebook under these conditions. The pilot lecture underwent an extensive evaluation. Before and after the lecture

the students had to fill out questionnaires to enable us to find out the problems and benefits of this new form of teaching. Most students expect an added benefit if notebooks are used in their professional education. The main reasons not to participate were monetary restrictions: some students can simply 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 conventional lecture in the winter semester 2001/2002 (WS 01/02) and as 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 questionnaire. 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.

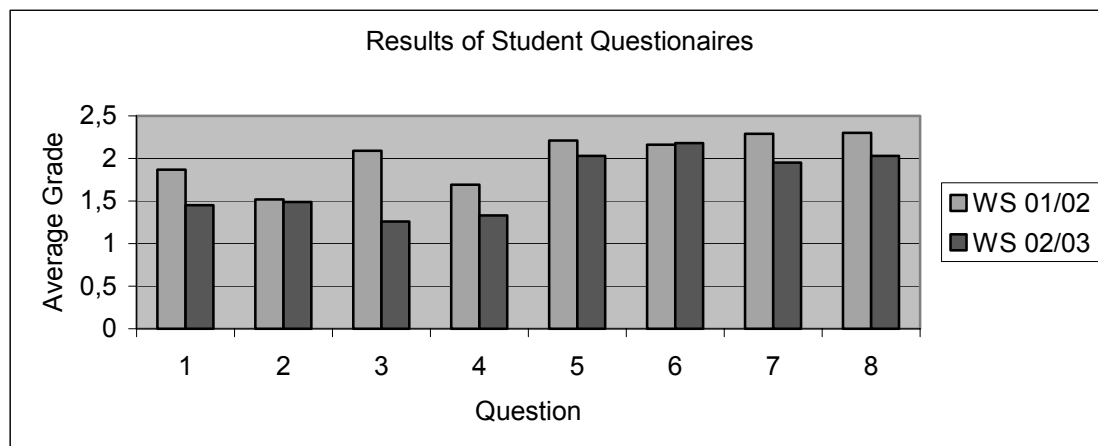


Fig. 5: Evaluation of questionnaires

In summary, the students were very pleased with both, the support for a notebook and the interactive lecture. 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 through the improvement in usability and services this will also be true for other sciences in the near future. In mid range time, the Microsoft tablet computer seems to be a better solution but it is too expensive for the students right now.

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 a 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 working 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 preparation of 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 man power 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 [4] will provide a more intuitive way to communicate in wireless ad-hoc environments.
- The interactive teaching and learning paradigm calls for more student activity. Learning by doing was especially simple to implement in the context of a lecture teaching the principles of operating systems. The “doing” part was provided for by giving the students access to a Unix server. For other topics like processor architecture or, say, archaeology, it is much more demanding to let the students make their own experience. In these cases, simulations will have to replace the reality. We are working on virtual prototypes which allow a software or hardware designer to test and debug their designs by inserting them into a close-to-reality environment and run them with realistic use cases.

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