

Dagstuhl Seminar 98051:

# New Media in (Computer) Science Teaching at University Level

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# **New Media in (Computer) Science Teaching at University Level February 2-6, 1998**

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This workshop brought together 25 researchers from various disciplines with considerable experience in the use of networked computers for teaching science topics at university level. They came from Germany, Austria, Switzerland, UK, and the US.

Currently there is a flurry of activities in promoting networked computers, in particular the World Wide Web as new media for teaching at university level. There are many scientists and teachers active in the field who develop interactive web pages, animations and simulations for educational purposes and contribute to the establishment of electronic libraries. The extension of data networks to information highways, providing high speed communication facilities to university teachers and students has the potential of triggering a revolution in the way that teaching and learning at universities will be done in the future. In particular, computer scientists have always been at the forefront of this development. This became obvious also during this workshop. There were quite a number of convincing examples for using computers for teaching computer science topics. Demonstration of a web-based course on Crypto Systems (Kaderali), the interactive manipulation of advanced geometric structures (R. Klein), and the visualisation of abstract concepts in compiler design (St. Diehl) are just a few examples. During this seminar it was also demonstrated that not only computer science can gain quite a lot from the new facilities. Similar experiences were also reported from Mathematics, Chemistry and even Humanities.

Participants of this workshop not only gave reports about their work and experience in the traditional way by a talk using blackboard, chalk, and transparencies. Almost everybody also gave at least a demo of software or courseware, respectively, illustrating the work. A few participants even participated in the experiment of getting their presentation recorded and post-processed for later replay by using new tools.

Besides the presentation of new multimedia content as CD-ROM or web based products or as a combination of both, the current status of the tools and their development played a major role. It became apparent that we are still far away from the ideal situation that producing multimedia documents for teaching at university level is as easy as producing a purely paperbound document.

Experiences in using networks for teleteaching experiments were reported, the vision of how to extend the communication facilities provided by the web in order to establish a virtual university offering all and even more facilities traditional universities currently offer to their students was presented, and, finally, the political implications

were discussed.

There was ample time for both formal and informal discussions and a final discussion round identified the following major issues.

### 1. Systems technology

One of the main problems in this area seems to be that people working in the field do not know enough about each other and about projects carried out at various places. That is, there is no established group communicating ideas and results such that all can benefit from each other. The impression of activities from web presentations seems to be quite different from what participants could see and experience during this workshop. Hence, even though it is important to be present in the web, workshops like this one bringing together people working in similar or related areas are highly welcome.

As one of the crucial points it was stated that establishing large repositories with multimedia teaching material would be desirable. However, it is time- and resource consuming to establish such a repository, to guarantee the quality of its content, and to make it accessible over a long time. This cannot be done without substantial support. It was discussed whether this might be a natural task for scientific organisations like the ACM or GI (in Germany) or whether it would be considered as a future service of publishing houses. For computer science and mathematics initiatives establishing those repositories have been established both in Germany and in the UK the association for learning technology (ALT) is a centralized interest group which seeks to bring together all those with an interest in the use of learning technology in higher and further education.

Further information on the Association for Learning Technology can be found under <http://www.warwick.ac.uk/alt-E>; and the CTI centres for computers in teaching are found under <http://www.cti.ac.uk/centres/>.

It became very clear that we are still far away from the ideal situation that university teachers can rely on repositories of easy to use, high quality, well designed material which they can directly incorporate into their on-line or off-line courses.

It became furthermore apparent that authoring tools are extremely diverse and not integrated into a single useful system. What is necessary is to observe modularity, to be able to guarantee link consistency. Authoring tools must be suitable both for the web and for producing CD-ROM publications. They should be platform independent, scaleable and allow the use of existing modules.

### 2. A role of technology and its impact on teaching

Most participants said that the use of multimedia material and of networked computers certainly influences their teaching style. There was agreement that using such materials does not make traditional lectures obsolete. However, such use

may change the role of university teachers such that they become information mediators more than presenters.

### 3. Differences between humanities and science (including mathematics)

In humanities lectures do not play such a central role as they do in science and mathematics. Humanities are much more interested in libraries. On the other hand, the use of video, photography, and other visual media seem not to play such a crucial role in computer science as they do in humanities, medicine, biological sciences and so on.

On the other hand there are many similarities between traditional teaching and in teaching using new media. For example courses of the drill and kill type or following established didactic principles for teaching play a similar role in both worlds.

### 4. Political issues

Here it was mentioned that some kind of public awareness is necessary in order to support research in this area. As a very good example of how web-based material can be used for promoting a subject, the on-line magazine developed in Cambridge was presented. Participants agreed that a similar on-line journal for computer science would help to give both students at high schools, and politicians a better insight into the field and may lead to the result that the currently observed decrease in enrolments can be overcome.

Finally it was considered as an important task of the community to provide politicians in particular with understandable information such that they can estimate the current state of development in networked multimedia and its use for education and thus get a better realistic view of this field.

# **Authoring on the Fly**

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We report about a series of experiments to merge apparently different tasks like teaching in class, telepresentation, and multimedia production into one single task. A key tool for this approach is an electronic whiteboard. We started using the wb of the MBone toolset which provides the teleteaching facility over the MBone multicast net. An integrated recording and replay environment has been developed by which the action streams generated by a lecturer (audio-, video-, whiteboard action stream) can be recorded and postprocessed s.t. the resulting documents can be integrated into hypermedia teaching- and learning environments. Over the last two years several researchers from different universities have used the system in order to produce a multimedia book on principles of algorithm design which contains papers, slides, animations, simulations, and recorded lectures linked together by using standard tools.

# Using the “Authoring on the Fly” Whiteboard

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The AOFwb is a new whiteboard for telepresentation and teleteaching. It supports recording the whiteboard and the audio stream. The actions on the whiteboard can also be transmitted by using mbone and received from the AOF-receiver. The most useful features of graphic editors are implemented. This talk introduces and gives an overview of the main features which make this tool an ideal computer-based substitution for both blackboard and overhead projector.



# **The Digital Lecture Board**

## **A Teaching and Learning Tool for Remote Instruction in Higher Education**

Wermer Geyer, Wolfgang Effelsberg  
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We present a novel, integrated teaching and learning tool – called digital lecture board – which takes into account the requirements of synchronous, computer based distance education. For almost two years, the TeleTeaching project Mannheim–Heidelberg has been using video conferencing tools for transmitting lectures and seminars. These tools prove to be insufficient for the purpose of teleteaching since they are not powerful enough for the use of media and for supporting teamwork while being somewhat difficult to handle by non-experts. We discuss shortcomings of the existing tools and present features we had in mind while designing the digital lecture board. Embedded in a teaching and learning environment, the digital lecture board even allows for asynchronous usage modes, for instance, the preparation of lectures. Moreover, the presentation covers implementation issues of the current prototype and future directions in our project.

# **Algorithm Animation in Compiler Design “From Hard-Coded to Generated Animations of Compiler Phases”**

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In this talk we gave an overview of the research on learning software for compiler design developed at Saarbrücken. We started by explaining how algorithm animation in compiler design differs from traditional algorithm animation. We briefly discussed the different compiler phases and their underlying computation models. Then we presented a PC-based learning software for compiler design which was implemented using an authoring software. We showed animations of examples for lexical, syntactical and semantical analysis. Then we argued that these animations have been hard-coded and that animations generated from formal specifications of a compiler phase would be more flexible and cost effective but moreover allow for explorative learning. We demonstrated a first web-based prototype which given a formal specification of an abstract machine generates an interactive animation of this machine. Finally we pointed out some future plans.

## **Lecture 2000 – Information Space**

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Lecture 2000 aims at supporting and enriching common university lecturing by applying the potential of the new technologies and by designing and implementing an integrated multimedia-based learning and teaching environment. It provides a comprehensive information space and supports collaboration facilities which may be used both by students and lecturers and which support their communication and collaboration needs.

Since 1996 the web was repeatedly used for electronic dissemination of educational material, for online teaching as well as private studying. The talk covers the didactical and technical concept for our web-based courses as well as our experiences using them in different teaching scenarios.

# **Virtual University**

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The concept of a university is presented which exports all its services to the users via electronic communication. The approach is comprehensive and thus includes all aspects of teaching (learning material, communication, group work, coaching, social contacts . . . ), but also administration, library access and integration with the workflows of the university. The way students work on this environment is presented, various experiences are described.

# Teaching as an On-Line–Service

## Vision and Reality

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**The Vision:** Place and time independent, individual, flexible and need-oriented efficient learning; just-in-time teaching; users get exactly what they need and download it instantly; online classes, seminars, individual tutoring and advise.

**The Reality:** We found in one project “Virtual University” in Hagen/Germany restricts us in realising all our visions. Main constraints are: hardware & software costs; experience students (particularly of new technical faculties) have with computers; available bit rates and their costs; development costs of animations, simulations and experimental environments; Student's attitude (particularly in Germany) that “university education is free anyway”; problems of copying and copyright.

**On the Horizon:** We see things changing: price drops in hardware & software; more experience in telecommuting; cheap storage, new subscriber loop technologies and huge price drops in transmission and switching; better authoring tools; push and pull technologies; individual info-managers.

### **How long yet to wait?**

5 years for adequate technologies

20 years for new teachers/professors!

# Animation, Experiment, and Laboratory

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Multimedia applications in education allow two goals to be reached at the same time. We can design new types of courses that make studying easier, more interesting, and perhaps more efficient. In addition, we can provide students with experimental environments that were not possible before fast hard- and software became available.

In this talk we try to classify such tools by increasing degree of interaction.

At the basic level there are *animations*; they are essentially moving figures that may or may not be explained by text or audio. As an example, we show what happens in a Voronoi diagram as more points are added.

At the next level, there are *experiments*. They allow for interactive control of parameters and/or dynamic behaviour. Students can use them for quickly creating examples, for finding out new facts for themselves, and for testing conjectures. The tools available at present include a Java applet named *VoroGlide* for interactive generation and continuous manipulation of 3D Voronoi Diagrams, Delauney triangulations and convex hulls.

Finally, we discuss the role of virtual laboratories, and give examples of some modules to be integrated into a robot lab, namely an applet called *Scout Step* that illustrates how an autonomous mobile robot explores an unknown polygonal environment.

This work has been done jointly with Ch. Icking, P. Köllner, E. Langetepe, and L. Ma. It has been partially supported by MWF, NRW, and is part of the project “Virtual University”.

Applets are available at

<http://wwwpi6.fernuni-hagen.de/>

# **The Impact of Computational Technology on the Teaching of Mathematics**

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This talk concerns the impact of computers on the teaching and learning of mathematics. It starts by showing that students currently often come to the university viewing mathematics as a subject they learn procedures, but they do not expect to be asked what procedure to use. It then descubes approaches to this problem, with examples from the Calculus Consortium based at Harvard. The examples focus on the note of the calculator or computer in getting the students to develop a conceptual understanding of mathematical ideas. In particular, the use of technology can encourage students to relate different representations of the same mathematical idea: Translating between the graphical, numerical, and symbolic representations is a powerful method of building understanding.

# **Use of Visualization in Teaching Introductory Computer Science**

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We describe a number of ways in which the use of simple graphics, visualization, and animation can enhance the teaching of introductory computer science. These include programming with graphics output, simple animations, algorithm tutorials with visualization, and exercises that introduce applications of computer science. This type of programming projects provide visual feedback for debugging as well as the setting for exploration of ideas and patterns. We then look at the role of experimental analysis in learning about the behavior of algorithms.

Finally, we explore the problems with dissemination of project oriented curriculum materials and propose a format for an online depository.



# **Learning with Multimedia in the Humanities**

## **A constructivistic perspective**

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I shall demonstrate two applications, a program for learning statistics in psychology and a program for learning the psychological method of cooperative counseling.

1. The first program shall illustrate the consequences of shifting the focus from teaching to learning. The statistics learning program represents a cognitivistic type of learning, discovery learning on the basis of a foregoing analysis of cognitive learning difficulties.
2. cooperative counselling of practitories and teaches in a typical humanistic subject; understanding in the central concept which involves understanding multiple views; decision taking in chosen as a learning strategy.

The presentation will extend to an overview over constructivist learning environments and the requirements for developing multimedia applications including scenarios, action oriented navigation, contextual cognitive information, and an exchange of meaning.

## **Poor man's multimedia**

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In this presentation we will see how to use readily and widely available tools like spreadsheet programs and freely available interpreters for languages like LOGO or LISP to create learning environments with high interactivity. The examples will cover topics like systems dynamics and difference equations, statistics (including Monte-Carlo-simulations), and music. These examples will serve as a starting point for a discussion of the relationship of technology and learning environments. Basically, we will try to show that by making creative use of existing technological resources, we can produce innovative didactical material where the emphasis on innovation is more on the side of “having a fresh look on old problems” than on using the latest technological tools.

Many of the examples shown are available at

`http://sunsite.univie.ac.at`

# Developing Teaching and Learning Environments

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While it remains unclear which effect hypertext and multimedia have from the pedagogical point of view, technical aspects in teaching and learning processes may be identified by viewing artifacts as an external memory.

Based on this approach, we describe the stepwise development, use, and evaluation of a teaching and learning environment that has been established over the past four years at Paderborn University. One of the major components is a hypermedia server which is not only used for storing and retrieving course material but allows students to actively work with the material by producing own documents as well as annotating existing ones and cooperate with other students in shared workspaces.

The second major component described is the electronic classroom which is part of an infrastructure that guarantees accessibility to all material relevant in the teaching and learning process wherever needed.

Further developments that have already been started are the distributed development of course material and the establishing of an electronic teaching theatre.

# **ViSeL – The virtual DNA-Sequencing Laboratory & The Virtual School of Natural Science - Bio Computing Division**

Dieter Lorenz  
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In this talk an overview is given about two research projects.

**The ViSeL project:** The aim of this project is to develop a CBT application and to improve methods in the field of genetics and molecular biology laboratory education. A virtual laboratory has to be realised, evaluated and brought onto market. Starting from this point methods and software tools will be implemented and developed, which will help to reduce the enormous expenditure during construction and care of virtual laboratory environments (Generic Biology Learning Laboratory - GenBill).

**VSNS - Bio Computing Divison:** We demonstrate prototype components of a “Globe-wide Department of Bioinformatics”.

The offerings are:

1. A two month interactive course in Biocomputing, in which small groups of approx. 6 students and one instructor meet in real-time via an electronic conference system in the Internet;
2. A “Study Project Agency”, which allows students to work on a half-year project proposed and guided by an experienced researcher via the Internet;
3. A “Sequence Analysis with Distributed Resources” tutorial, which offers advanced exercises, simulations and background material.

# **Database-centric authoring and distribution of multi-/hypermedia applications**

Scott Dynes

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This talk makes the case that databases aid authoring and distribution.

Authoring today involves managing large quantities of media objects, a task where databases have excellent capabilities.

For distribution, the abilities of databases to be remotely accessed and written allows for the updating of content and scripts, provided that hypermedia applications query databases for content and actions.

For distance education the ability of databases to be synchronized remotely allows for a transparent method of communication between student and teacher.

# **Knowledge Management in the Learning Organization**

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This talk describes how knowledge needs to be managed and organized to be of optimal use for knowledge-intensive companies. It first defines general document management, information management, and knowledge management architectures. It then discusses the knowledge creation process. The next part describes how knowledge needs to be stored and made available for optimal access and retrieval. It is based on the “seven design concepts for navigation in cyberspace” outlined in the book “Elements of Hypermedia Design” by Gloor. The final part presents an actual system for the visualization of large information spaces, Cyber Map, which has been built by Gloor and others over the last five years.

# **From the History of a Future Shock**

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Computers change the way we think of teaching and learning. This is in apparent contrast to the fact that education as a social process was only to rely influenced from media technology - though every new media technology was propagated as a means for better education.

The lecture was invented together with the early European universities around 1150 - the same time when the structure of manuscript was defined. Structured manuscripts were copied and preserved in the printed book - invented three centuries later.

Other media technologies like photography, telegraphy, radio, telephone, or TV did not influence school or university lectures very much - with the notable exceptions of large blackboards in the 17th, and Xerox copiers and overhead projectors in the late 20th century.

This leads to the question, why and how technology may influence form and content of education processes.

# Motivating Mathematics

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This presentation has two parts:

1. “Calculus Connections”
2. “PASS Maths”

Calculus Connections is a multimedia package produced in collaboration with Dr. Douglas Quinny of the Univ. of Keele (UK) and J. Wiley Inc. (USA). Its materials are designed to motivate the study of Calculus in a typical US “freshman Calculus” course. It covers topics from “idea of function” to “vector calculus”. It is produced as a 3-volume set, 8 minutes per volume, and a Laboratory book accompanying each volume. Each module contains the following components which may be accessed at will by a student: 2 *applications* (multimedia presentations of a topic), 3 or more *concepts* (in which some detailed maths is explained with the help of simulations and other forms of interaction), and *exercises* (including the use of computer algebra). The package intend for use always the other method teaching/learning, and makes special use of those features where computer methods do things that cannot easily be done by other means.

PASS Maths stands for “Public Awareness and Schools Support for Mathematics”. The project produces an on-line magazine ([pass.maths.org.uk](http://pass.maths.org.uk)) focused on ages 15 years upward. Using plain everyday language, it contains: features on the relevance and importance of maths in the modern world; puzzles (to excite interest and thought); articles on “mathematical mysteries”; cancer profiles; letters page; section (*Staff Room*) of interest to teachers. It is published three times per year (January, April, September). Articles are contributed from all over the UK (and abroad). Evaluation is done through questionnaires at collaborating partner schools.



## **The Virtual Learning Lab and more ...**

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Technology can be implemented in the humanities when it is easy to use and when its implementation is an obvious advantage or enhancement over existing approaches. Since straightforward “yes/no”, “true/false”, or even multiple choice type of activities cannot satisfy the serious humanist, other activities are necessary that can be integrated into existing curricula and that can possibly improve the quality of instruction.

These activities are those that utilize computer technology where it is best: 24 hours access, direct (clickable) access to text, sound, and video as well as the capability to conduct essential behavioristic drills in certain areas of language instruction, and the ability to use tools to handle authentic materials, particularly text, for integration into the curriculum.

By showing several examples of Dartmouth-developed software the speaker will demonstrate what kind of activities and interfaces can fulfill some of the criteria without offending the humanist. The speaker will also provide some comments on library interfaces, electronic mail, databases on the web, and some demonstrations on how to maintain them.

The speaker will also comment on the Supermaclang environment that permits construction of contextualized language learning/teaching activities.

# **A Multimedia Publication on Principles of Algorithm Design**

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We present the production process of an innovative coursebook extending conventional knowledge-mediating paradigms by efficiently introducing dynamic and interactive media for use in the electronic version of the publication. In particular, we address the various problems encountered in generating the individual modules in formats suitable for electronic publishing, in particular document conversion, integration in the context of open environments, re-use of publicly available modules, platform-independence and migration from authoring formats (primary) to publication formats (secondary). After a demonstration which also includes focusing on effectively using different modalities, the integration into publications in other contexts, such as local networks and electronic libraries, is addressed. We conclude by pointing out possible techniques to enhance and promote the active use of electronic media, such as annotation techniques, data stream indexing, and active control of external applications.