

# Telematics for Education and Training

Proceedings of the Telematics  
for Education and Training Conference  
Dusseldorf/Neuss,  
24-26 November 1994

Edited by

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*FIM-Psychologie, Erlangen, Germany*

1995

**IOS Press**

Amsterdam, Washington

**Ohmsha**

Tokyo, Osaka, Kyoto

*Amsterdam, Oxford, Tokyo, Washington, DC*

# Adaptive Learning with WWW: The Moscow State University Project

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## Abstract

*Existing WWW educational systems are non-adaptive. It is the overall goal of the project started recently at the Moscow State University (MSU) to combine the 'distance education' potential of WWW with the 'adaptive education' potential of intelligent tutoring systems. In this paper I will describe the background work of our group on adaptive educational systems, the approach we have developed and the method of applying this approach to adaptive WWW-based distance education.*

## WWW Features

Distance learning and educational telecommunications open new ways of learning for many people. Now an educational programme or learning material installed and supported in one place can be used by thousands of students all over the world. World Wide Web (WWW) and WWW browsers provide a good example of powerful modern telecommunications facilities. Using WWW, a novice user can comfortably browse the Internet in order to find required pieces of information in different locations worldwide. From the very early days of WWW there were several attempts to use WWW facilities for distance learning. However, being a good general tool for Internet navigation, WWW and current WWW browsers are not specially designed for distance education. Thus most existing educational WWW applications use the simplest solutions and are much weaker and more restricted than existing 'on-site' educational systems and tools. A number of powerful technologies which prove to be very effective in 'on-site' education are still not implemented within the WWW framework.

One of these technologies is the adaptive educational systems technology, which was developed in the field of intelligent tutoring systems. Adaptive tutoring systems use the model of the student to adapt tutoring and the learning process to the student concerned. Existing WWW educational systems are non-adaptive. WWW is powerful enough to support adaptive education, but special research and design work have to be done to support adaptive educational systems technology with WWW. It is the overall goal of the project started recently at the Moscow State University (MSU) to combine the power of 'distance education' provided by WWW with the potential of 'adaptive education' supported by intelligent tutoring systems. This project is introduced briefly in the following sections.

## Background of the Project

Our group at the Moscow State University has long had experience of developing adaptive educational systems for several fields such as programming, databases, geography, calculus and geometry. Since 1984 we have been investigating techniques for adaptive course sequencing (Brusilovsky, 1992). The systems with adaptive course sequencing use a student model to select the next topic or concept to be learnt and the next teaching operation (explanation, example, problem) to be presented. These systems belong to the class of 'tutoring' or computer-run

educational systems. Later we started new research on adaptive hypermedia systems (Brusilovsky, Pesin & Zyryanov, 1993). Adaptive hypermedia systems bridge the gap between computer-run tutoring systems and student-run educational environments. Leaving the initiative to the student, they use the student model to adapt the content of the hypermedia pages and the layout of link to the student. In particular, they can be used to guide the student implicitly. Our recent systems (Brusilovsky & Zyryanov, 1993; Brusilovsky & Pesin, 1994) use both adaptive sequencing and adaptive hypermedia technologies and can thus adaptively support both computer-run tutoring and student-run learning. They are based on a knowledge-based approach developed by our group. We have implemented this approach in several systems and are interested now in applying it to adaptive distant education.

## The Idea of the Project

The goal of our new project is to apply our adaptive sequencing and adaptive hypermedia technology in the field of WWW based education. We plan to design an authoring tool (a shell), which can be used by a human tutor to design adaptive courseware for distance education.

Special editors will help the teacher to present the information about the field concerned and to design the set of teaching operations. All information will be presented in the form of frames.

Using these frames, the authoring system will generate courseware for distance learning which will be a combination of HTML files, knowledge frames and programme scripts. From then on, this courseware can be used by anyone who has an access to WWW and Mosaic-like browsers and wants to learn.

Working with the adaptive courseware, the students will have a navigation support for all the choices they have on a particular page. In accordance with the level of knowledge and educational goal of a particular student, all the links will be individually 'provided with comments'. Some links can be hidden from the student, but some additional links can be generated. In particular, any page will have a dynamic 'next' button. Activating this button will start the system's intelligent sequencing mechanism, which selects for the student the next 'best' or teaching operation. The content of the hypermedia pages will also be adapted to the student's current knowledge. Students who see the educational material for first time will get more explanations, but some second-level details will be hidden to protect them from cognitive overload. When they are browsing through already familiar material, they will get fewer introductory explanations but more high-level details.

To achieve this high level of adaptivity most of the hypermedia pages which the system presents to the student will not be stored in the HTML or text format, but will be adaptively generated (depending on the student model) from the knowledge base by the scripts attached. This possibility is now supported by most WWW servers via Common Gateway Interface (<http://hoohoo.ncsa.uiuc.edu/cgi/>). Our system will also be able to accept and analyse students' answers and solutions to problems. This feedback allows the system to keep the student model updated. Here we rely on another relatively new feature provided by a recent version of WWW viewers: fill-out forms. We are very pleased that WWW is now flexible enough to implement such an adaptive mode of work. Of course, we cannot implement with WWW all of the features which we have in our 'on-site' systems, but we hope that forthcoming features of WWW and WWW browsers will make distance education courseware as powerful as any 'on-site' course-ware.

## Project Details

The project is being carried out in the Research and Education Laboratory (RED LAB) at the Applied Mathematics and Cybernetics Department. Several professors, staff members and students of different levels are involved. At present we are using SUN SparcStations with NCSA Mosaic. The work on authoring tools will be done in conjunction with the design of the first adaptive distance education course 'Introduction to UNIX'. We have chosen UNIX as the first field of application because this course is important for the students in our department and because no external experts in this field are required for it. Our adaptive UNIX courseware is

**Peter Brusilovsky** expected to be used not only as a UNIX self-study resource but also as a UNIX adaptive reference manual.

Once the authoring tools are ready to be used by external experts in various fields, we plan to implement courses on theoretical mechanics and on medical diagnostics in cooperation with other departments of MSU.

## Additional Sources of Ideas

We outline the following local areas of research as sources of good ideas for the integration of hypermedia and intelligent tutoring technology:

- o frame-based ITS authoring tools,
- o work on the indexing of learning material and the re-use of courseware,
- o work on adaptive hyper-media.

On the subject of ITS authoring, we should mention such authoring systems as ECAL (Elsom-Cook & O'Malley, 1990) and SHIVA (Zeiliger, 1993). These authoring systems are based on both CAI and ITS paradigms. The teaching material is not generated as in 'orthodox' ITS, but stored in a kind of frame. However, this representation is based on explicit domain model network, so all these frames can be selected intelligently.

On the subject of CAI and hypermedia authoring side we should mention the work on indexing the teaching material. In our approach all teaching operations have a weighted index (spectrum) of related concepts which is the basis of the knowledge-based sequencing of teaching operations. In the hypermedia area an idea for a method of indexing was elaborated by Mayes, Kibby and Watson (1988) in the StrathTutor system. They stress additional preference for indexing the frames of learning material - the possibility of indicating related pairs of frames not by the tedious manual linking of pieces of learning material together, but dynamically, on the basis of a similarity of corresponding sets of topics. The indexing of learning material is also used in authoring systems based on the courseware re-use paradigm. Indexed sets of frames are not related in accordance with any prescribed order of presentation. They can be accumulated, stored in special libraries and re-used by different authors wishing to create their own courses. In a multimedia field the idea of a re-usable database of multimedia learning material indexed by topics and keywords is elaborated by Olimpo et al (1990). We think that an indexed database of learning material is a good step towards a knowledge-based hypermedia authoring system. The next source of ideas is the work on adaptive hypermedia, which is a recognized area in the field of adaptive interfaces.

As has been pointed out above, adaptive hypermedia combines free browsing with individual support and can support the entire continuum of learning modes between purely system-controlled ones and student-controlled ones. Here we wish to mention just two directions of work on adaptive hypermedia: the work on adapting the content of a hypermedia page (Boecker, Hohl & Schwab, 1990; Beaumont, 1994) and the work on adapting the order or the layout of links to related pages (de La Passardiere & Dufresne, 1992; Kaplan, Fenwick and Chen, 1993). A very recent work by Kay and Kummerfeld (1994) reports on some ways of implementing adaptive hypermedia with WWW

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