Knowledge-Based Navigation Support in Hypermedia Courseware using WEST

John Eklund
Faculty of Education, The University of Technology, Sydney
j.eklund@UTS.edu.au

A version of this paper was presented at The First World Conference of The Web Society, WebNet96 [HREF4] in October 1996

KEYTERMS

Introduction

New technologies which implement on-line learning are a key component in the flexible delivery of courses. Alternate strategies for course delivery based on computer mediated learning are a part of flexible learning design (Scott, 1996). A problem with on-line learning identified in recent literature (Pennell 1996, [HREF2]; Jones 1996, [HREF3]) has been to provide quality interaction with students through individualised instruction, customised course material and a personalised dialogue with learners. Providing a passive information source typical of even carefully sequenced Web documents has the problem of learners becoming disoriented. This is not meant to say that they may not know how to get back to where they want to be by deliberately using the navigation aids that a browser such as Netscape provides. Rather, the problem of information overload and distraction on the Web causes learners to lose focus on learning objectives or information seeking tasks. Recognising this, the aim was to implement a system [HREF12] which provides immediate feedback to students and attempts to address the problems experienced by learners in navigating hypermedia courseware. On the basis of the student’s results in on-line testing modules, the system provides individual navigation support to guide the learner through the courseware. The Web-based courseware (or Webware) presently consists of eight subsections each of which has a set of outcomes, a prior knowledge test, pages of instruction, a set of exercises to be completed for the face-to-face sessions, and a topic test. The knowledge-based system is currently adaptive [HREF5] only in the simplest sense, but is specifically being used as the basis for an empirical study which aims to determine whether link annotation [Brusilovsky, 1996] to provide individual navigation support improves learning outcomes for students.

Adaptive hypermedia systems

Adaptive hypermedia systems are a relatively recent area of research which combine two technologies in computer assisted instruction, Intelligent Systems and Hypermedia Systems. The former are
knowledge centred and have the ability to individualise instructional sequences by modifying content or presentation based on the interactions with the student. Most hypermedia systems are predominantly a non-pedagogical technology (Duchastel, 1992) in which learning relies on the user’s interest and purpose through the use of a variety of navigational aids in a database of hyper linked information. There has been some interest in combining the two technologies (Jonassen & Wang, 1990; Costa Pereira et al, 1991; Duchastel, 1991; Douglas, 1994). It is in effect a combination of two opposed approaches to computer assisted learning: the more directive tutor-centred style found in knowledge-based systems, and the flexible student-centred browsing approach of a hypermedia. As teachers and as learners we know that neither style is exclusive of the other. The level of structure in teaching and learning depends on the content, the learner, and the medium through which it is delivered. An adaptive computer-based learning environment attempts to “know something” of the learner, and adjust or advise instructional sequences accordingly.

Brusilovsky [HREF7] provides two categories of features which can be dynamically adapted in an adaptive system: Adaptive presentation and adaptive navigational support. In adaptive navigational support (Linard & Zeiliger, 1995; [HREF9]) the space of possible paths which can be followed by users may be tailored. This style of adaptation addresses the problem of hyperspace disorientation by providing guidance. Adaptive navigation is implemented in this instance in a more or less static hyperspace, adjusting link annotation according to the individual knowledge of the user. This knowledge-based navigation support is appropriate for courseware with well-defined and largely declarative knowledge.

**The WEST tool for delivery of courses**

Two central components of an adaptive hypermedia system are a mechanism to deliver it and an authoring tool to create it. For the former the Web was the obvious choice for this project, as it is a distributed, widely accepted medium which allows materials to be accessed and continually updated. The courseware exists centrally and the users of it are distributed. Using a well-supported and professionally developed system as the central authoring and delivery component and attempting to modify it reduces the effort required to build the adaptive system, and enables the authoring effort to be later utilised for purely teaching purposes. WEST was chosen for its robust nature, its competitive price and the fact that it is becoming a popular software item for computer mediated instruction, being used in over 17 countries (Lennox, 1996) by universities, technical colleges and training institutions. The WEST company maintain a discussion list (West-talk@west.ie) through which the software is being evaluated, improved and supported. The current version provides enhancements which allow the robust delivery of purpose-designed Web-pages and incorporates a log-in procedure, the allocation of students and tutors to classes, email to individual students and between students, class announcements, discussions, the automarking of multi-choice tests, and submission of assignments via the internet.

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**Restructuring the subject**

The subject delivered using WEST in this instance, Educational Computing 3, is concerned with the use of the Web in education, and has two components: The technical aspects of the Web including coding hypertext markup language (HTML), and the place of the Web in the classroom and the instructional theories on which it is based. It is the technical component that features in the courseware pages, and student’s progression through the eight sections is assessed via a prior-knowledge test and a topic text in each section, each test consists of 10 multi-choice questions. Along with working through the materials at a rate of one section per week, students participate in on-line discussions about readings which are posted on a ‘readings page’. These are typically papers relating to the teaching and learning aspects of the Web. Students meet the lecturer for a three hour session each fortnight, the aim of which is to
support the online work, provide some hands-on instruction, and for the students to receive help with, and submit the exercises set for, each section. The auto-marked tests assess student's acquisition of the declarative knowledge embodied in the course pages. Students are also assessed by a major project or essay, the section exercises and their participation in discussion about the readings.

**Infrastructure requirements**

The Web is a new technology and it is not yet as reliable as the telephone. Students were supported by the Faculty in being given dial-in access from home, and about 10 of the 40 students capitalised on the offer. This in itself requires considerable technical support, as UTS does not as yet generally provide this service to students. The remainder of the students accessed the courseware from the computer lab during open access times. Problems have been encountered with computers ‘crashing’ because of the speed of the network, insufficient memory on some computers, and software incompatibilities. Most students have reported having to reboot their machines at least once in the first week of the course. This should be evident from the audit trails being collected. Moreover, the students themselves did unexpected things. While most students printed the page of exercises in each section, some students are printing all of the pages of each subsection and reading them as hard copy. This made the hypertext links difficult to see and impossible to follow. Some students appeared to be answering the questions one or two at a time, looking at the question then returning through the pages to search for the answer.

Many students have reported frustrations in accessing the coursework in the labs as they tend to be enrolled in the same subjects and options and thus have the same time free of lectures to use the lab computers. There are clear and obvious implications for the provision of adequate technical support and hardware in implementing computer mediated instruction, particularly with such developing technologies as the Web.

**Courseware architecture**

The architecture being implementing places WEST within a frameset in which the main frame contains the course pages, and the navigation buttons of WEST, just as the WEST interface usually appears. The courseware thus requires Netscape version 2.0 or higher to be viewed. The course pages include hyper links to relevant materials on the Web, so that students may investigate resources already on the Web related to the topic. These hypertext links are targeted to a “blank window” so that students may ‘browse outside the courseware’ and easily find their way back. The ease with which Web resources may be integrated into the course is one of the simplest yet most effective elements of the system (or any system in which course materials are placed on sequenced Web pages). In this sense the courseware is both closed and open corpus (Ibrahim and Franklin, 1995). A typical subsection (figure 2) contains a statement of outcomes, pre and post automarked multi-choice tests, sequenced pages of instruction containing text, graphics and hypertext links, and a set of exercises.

**Modifying the WEST System for Navigation Support**

Students enter the course via a page which uses a script to hide the Netscape location, toolbar and the directory buttons, and establishes a frameset with a large frame at the top of the screen in which the WEST pages appear, and a smaller bottom frame in which a clickable overview map is generated for each student showing the hypermedia nodes and annotating the links as visited, unvisited, current and suggested. This map is loaded by a script placed in each of the course pages in the top frame, and uses Javascript to extract the “context” in which the course page is being delivered, that is, is able to recognise the student using the course. It also extracts the URL of the page loaded in the top frame, and thus can generate the links dynamically. After further development, it is proposed to generate the actual link set automatically as well, so that as pages of courseware are added, the overview map will update itself. This will take the form of a utility used in conjunction with the authoring of the pages. It will also show what page has been ‘learned’, and what pages have yet to be mastered, possibly by generating

![Figure 2: “Browsing out of the courseware”: hyper links are targeted to a new Netscape window](image-url)
Knowledge representation

A somewhat similar (and fully developed) system is ELM-ART (Brusilovsky, Schwarz & Weber, 1996), a critical difference between the ELM-ART system and what is being described in this paper is that in ELM-ART, once a student has visited a node, the system assumes that the student has read and understood the material at that node. In this way ELM-ART assumes that students are purposeful and deliberate about their movements through the hyperspace, it does not account for behaviours such as looking ahead at material before reading it, or reading material and not understanding it. A derivative of this system is INTERBOOK [HREF11] which aims to serve adaptive textbooks on the Web, using sorting of links and link annotation as the adaptive techniques used for navigation support.

Knowledge representation

To implement knowledge-based navigation support which annotates nodes as ’learned’ or ’unlearned’ implies that the system is acquiring information about the needs or knowledge state of the learner, and is implementing its advice according to some strategy. Individualising information and link-anchors (adaptive presentation) or providing the user with navigational support (adaptive navigation) is performed within a system on the basis of information kept in a user-model, the system’s representation of the user’s preferences, knowledge, beliefs, or information seeking goals. “They are

Table 1: Concept lattice for Test Items

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Attribute 1</th>
<th>Attribute 2</th>
<th>Attribute 3</th>
<th>Attribute 4</th>
<th>Attribute 5</th>
</tr>
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<tbody>
<tr>
<td>Y4.T(1)</td>
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<td>Y4.T(2)</td>
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<td>Y4.T(3)</td>
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</tr>
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<td>Y4.3</td>
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from the WEST database, and the ability of the system to write to a file, being the individual student model.

**Evaluation of Link Annotation for Navigation Support**

With the system under development, an empirical study is being undertaken to see whether the adaptive link annotation is effective as a navigation aid, and in improving learning outcomes. This is being done by disabling the navigation support for a random half of the students for the first part of the course, then enabling it for the second, and vice-versa. When the adaptive navigation support is disabled, the overview map remains a useful navigation aid, it simply does not annotate anything other than visited and current node. Audit trails and the results of the automarked online tests are being used for both the formative and summative evaluation.

There are some problems and limitations which may be identified at this stage. Firstly, the fact that the hypermedia is only 85 or so subconcept nodes and that in such a small corpus navigation support has limited effect, particularly as the nodes are already presented in such a structured way.

Secondly that the length of time over which the students undertook the course is rather long (8 weeks) and may produce somewhat disjointed audit trails. Audit trails, if not compromised by hardware/software problems may be revealing more about individual idiosyncrasies of students, such as looking back at pages to find answers to questions in the tests. Thirdly, the overview map provides an excellent navigation tool in its own right, and along with the navigation buttons of WEST, may reduce the effect of the adaptive annotation of the nodes for navigation support.

The results of the empirical study will be the feature of a further paper on this project.

**Acknowledgments**

Thanks to James Sawers of the Educational Multimedia Unit (EMU) [HREF10] of The University of Technology, Sydney for his expert technical advice. Without the availability of the specialised support of EMU this project would not have been feasible.

**REFERENCES**


