A PRACTICAL MODEL FOR THE DEVELOPMENT OF WEB BASED INTERACTIVE COURSES

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Abstract *— Web based courses are very important for distance education, the core business of our university. Hence we developed a model for the design of attractive and motivating web courses, which is easy to use and learn, and independent of browser and composing tool. The model presents learning atoms in consecutive steps on the screen, using interaction, images, audio, exercises and feedback, but little text per step. The learning material itself is entered in separate documents, following strict guidelines on grouping and naming. After uploading to the web, accompanying software shows the documents in the main frame of a three frames structure. Another frame contains an automatically generated tree menu for navigation. Problem solutions and a glossary appear in the third frame. The model supports seamless integration of web and cd-rom, personal student notes, feedback forms, external links and multimedia. The model is currently used for the development of new courses and the experiences are encouraging.*

Index Terms — Distance education, on line learning, web based interactive courses, hypermedia, web tools and model.

INTRODUCTION

Over the past eight years communication over the Internet has been growing exponentially. In particular the World Wide Web is expanding rapidly, and seems to fulfill the desperate need for information of the previous decades. A colourful spectrum of Internet applications is emerging from broadcasting company information through distribution of images and music, playing Internet games, retrieving information with search engines, to e-business. It seems only natural that educational organizations have been exploring the possibilities of using the web for teaching purposes. Even more so, as there appears to be a shift from self-contained educations to life long learning, where distance learning and learning on the job plays an important role.

Virtually every organization involved in innovation of the educational process, has put some effort into the development of web based courses (e.g. [1] - [5]). However, a real breakthrough of on line learning has not yet take place. The easiest and most obvious way of making web based courses, uploading electronic versions of printed courses to the web without modifications, turns out to be unsatisfactory. Students tend to print out the material, and still study from paper. The alternative, redesigning the courses to match the character and opportunities of the web, is a cumbersome process, and the most effective way of exploiting the new media and possibilities for teaching purposes is not known.

For the Open University of the Netherlands (OUNL), distance education and the innovation of the educational processes are its core business. As such, a few years ago, the OUNL started several projects to explore the possibilities of using the web for education, e.g. the development of the electronic learning environment Edubox®, based on the newly designed Educational Modelling Language [6], and the development of the Virtual Company learning environment [7], with training methods in a virtual environment and training on the job. The present paper is a report on the project Electronic Course Book (ECB) [8], focussing on research about the optimal way of presenting learning material on the web in electronic courses.

WHAT IS AN ELECTRONIC COURSE BOOK?

The purpose of the ECB project was to investigate the most effective way of presenting learning material on the web. Important issues to be addressed were:

- which platform and language to use
- optimal use of the computer screen
- efficient navigation
- the proper media mix
- the role and lay-out of text
- the use of fonts
- didactical models

The following definition of an electronic course book was adopted: a complete or partial learning module on screen, with dozens of hours study-load, consisting of a collection of hyperdocuments, menu-driven, with a functional use of interactivity and multimedia, presented on the web and/or cd-rom.

WHY AN ELECTRONIC COURSE BOOK?

There are several reasons for wanting to publish electronic course books (ecb's), apart from the world wide interest mentioned before. The presence of some commercial drive is undeniable; with our target group of potential students surfing the Internet in large numbers, the presence of appetizing sample courses on our web site easily leads to an increased interest in our educational program. A growing demand for web based courses is noticed, and of course we

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have to keep up with the competition, or rather stay ahead. Another reason is that web courses are much easier to update. At present, the development of a course in print takes about one year; after it is publishing a revision is not expected to happen within three years, as the duration of the revision cycle simply is that long. The third reason is the observed technology push: so much appealing new technology has become available which is to be explored, and tested for its effectiveness. The fourth reason is the potential delivery of higher education to remote or isolated areas.

The reasons presented above, however, are company motives, and do not have a scientific basis. On the other hand, we expect electronic course books to display several, more objective didactical advantages. These are:

- **Asynchronicity of teaching and learning**: an ecb allows students to study at their own pace, at the most suitable time and place. Due to the compactness of the available computer hardware (e.g. notebooks), instead of books, cd-roms could be carried around. Or, when new communication technology becomes available, students can log into the Internet any place, any time.
- **New features**: compared to text books, the web offers many additional features that may enhance the didactical effect, like interactivity, individualization, contact with tutors, feedback, quick referencing through links, easy use of colours, animations, video, and audio.
- **Course maintenance:** web courses can be updated or improved at any moment, whereafter the update is directly available to all students. Traditionally, the publication of a new edition of a text book is preceded by an in-depth study of all recent developments in the field. For web courses this is no longer necessary: each new development results in a direct update, soon after it is noticed. In addition, the door to incremental course development is opened. Parts of web courses may be released before the ecb is finished.
- **Alternative structures:** in contrast with text books, ecb's may have a non-linear structure, e.g. a tree-like hierarchy, or a graph. They also support individualized learning paths. Many text books make efforts to simulate non-linearity, by presenting learning graphs, but this requires a lot of discipline from students.
- **External links:** ecb's can tap virtually unlimited resources on the Internet, using direct links.
- **Integration of communication:** use of the web opens up new ways of learning besides the traditional transfer of knowledge, such as discussion groups, group learning, peer assessment, and learning by doing.

PROBLEM DEFINITION

The question is: if web learning offers so many advantages, why does it take so much time before it is widely accepted? In an early stage of the ECB project we found, in discussions with peers, a widespread reluctance to replace text books with ecb's. Many serious drawbacks of web learning were mentioned. The questionnaires accompanying small demo courses showed similar doubts. An analysis of discussions and questionnaires resulted in the isolation of various problems, connected to the introduction of ecb's. These problems are described below.

Compatibility

The equipment of students in the target group is very diverse. Different platforms and operating systems are being used, with different configurations and varying collections of software. It seems hard to design web courses that can be accessed universally.

Limited space on screen

Although the size and resolution of monitors steadily increase, the screen still remains a poor substitute for a desk covered with text books and notebooks with pages that can be easily turned and scanned. Arranging documents on a screen, as well as scrolling and paging through a screen document is experienced to be a annoying and clumsy It would take a very economic usage of the limited screen size and a smart way of browsing to overcome these problems.

Internet as a maze

The use of non-linear structures, promoted in the previous chapter, certainly has its advantages, but many users get lost in the maze of hyperlinks. Special care must be taken to assure that students have an overview at all times of what they are doing at present, which tasks they have completed, and which tasks still have to be performed.

Bandwidth

The large diversity in available hardware has yet another consequence: the speed of the connection to the Internet, or bandwidth, varies widely among students. It ranges from a slow 14K4 modem connection (or worse), through ISDN, to high speed cable or ADSL. This implies that many students experience slow data transfer, and hence long waiting times for web documents to be displayed on their screen. Sometimes this delay is increased even more by a lack of processing power of the cpu or the video card. For this group the transfer of large multimedia files, such as detailed photo images, animations, video or audio, is painfully slow. Studying a web course containing many of these multimedia items becomes very annoying.

Overhead

Designing and maintaining a web course, with a large collection of web documents, frame sets, menus, link structures, images and multimedia, potentially implies much overhead. Developing a balanced course is in itself a non-trivial matter, but if the design process is further complicated by such additional overhead, many course developers would refuse to cooperate.

Dislike for on screen learning

According to our inquiries, many students show an aversion to study courses on screen. This may be due to the lack of experience with the medium, but there may also be more objective motives. Reading from the screen is indeed rather tiresome, it is difficult to keep an overview of the content, and the reading position is certainly different from the one taken when reading a text book.

Comprehensibility and interest

A recent study [9] indicated that text, read from a screen, is experienced to be less understandable and less interesting than exactly same text on paper. It is suggested [10] that this may be due to the fact that text on screen offers less resting points for the eyes, because of the continuous video refreshment. Alternatively, it may be the case that to users the computer environment is felt to be a "fast" medium, with conspicuous images, simple icons, big headlines and flashing banners, which should be browsed quickly. It is hardly associated with the reading of large pieces of text in tranquillity. Whatever the case, the effect on the transfer of knowledge and the degree of persuasion is measurable, and should be taken into account.

Cost of being on line

Studying a course on the web usually means being on line all the time. For a regular course of about one hundred hours of study, the cost may be considerable. Neglecting the problem could raise serious objections from potential students.

SOLVING THE PROBLEMS

Trying to tackle the problems, we designed demo's, and had students and experts fill in web forms, inquiring about their opinions. While constructing the demo's we distinguished the macroscopic course structure (Java demo [11]), which included division of the screen, navigation and text lay-out, from the microscopic level of so-called learning atoms (demo "Coding of Negative Numbers" [12]). In this context a learning atom is understood to be a self-contained indivisible chunk of knowledge. The demo's were refined several times, various solutions for the problems were tried. This finally resulted in a model for the presentation of web based courses with more or less acceptable solutions to all the problems stated above. One by one the solutions to the problems will be addressed below.

Compatibility

The decision was made to use only material independent of platform or specific software. This requirement is met to a high degree by plain html, if we adhere to W3C standards [13]. Hence the player for an ecb could be any standard web browser. For the inclusion of interaction and multimedia, we rely on JavaScript and Java applets, jpeg and gif images, sampled sound, and gif animated pictures. All of these represent widely accepted standards, and can be displayed in most modern browsers. In the future XML could be used, or animations using Flash technology.

Limited space on screen

In order to make optimal use of the limited space on screen, the browser window is assumed to fill the entire screen, having a minimal resolution of 800×600 pixels. The window is subdivided into three carefully positioned frames (Figure 1). Pop up windows are avoided as much as possible, as they require additional actions from the user, and they block a part of the screen, which is considered to be annoying.

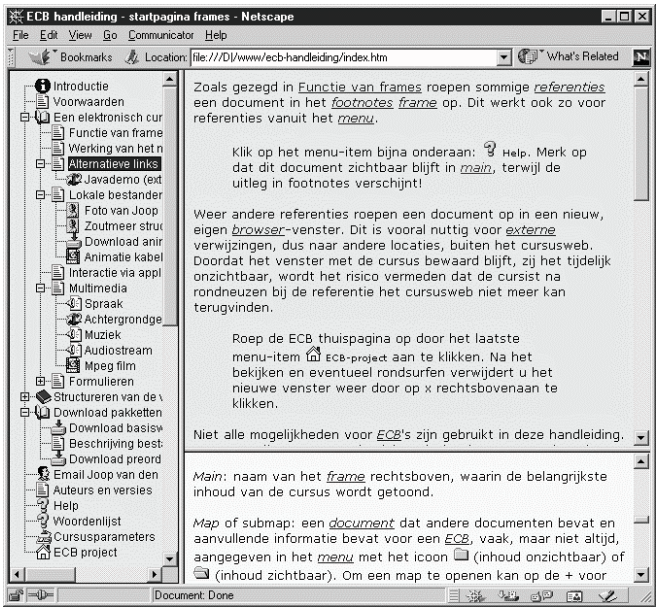

FIGURE. 1
SCREEN PRINT OF THE 3-FRAME STRUCTURE IN THE ECB-MODEL

The main frame on the right contains the contents. The left frame contains the menu. The continuous presence of the menu is considered indispensable, not only when using a non-linear course structure but also for linear structures. Remember: the screen is not a book where you may scan the pages by looking back or forward. The setup with a menu and a content frame is quite common (see for instance [14]). In our experiments, however, we added a third subframe, below right, for optional extra information. This frame is used for solutions to exercises, help, background info, parameter settings, student notes, and a glossary. When the frame is not used, some screen space is wasted, but the solution conforms to the desire to avoid pop-up windows. Some students reported that the subframe was too small. Therefore, it may be that at a later stage a third solution will be implemented, combining the advantages of subframe and pop-up windows.

The menu can be expanded and collapsed to keep an overview, while at the same time showing details locally where needed. Icons indicate the type of document, folder,

link or multimedia component. The menu structure is very similar to the directory structure in MS Explorer and Help, so it looks familiar from the start to most students. The reactions of students to the menu in the demo's were mainly positive. Some found the level of nesting too deep.

Internet as a maze

To avoid that students get lost, the structure of the ecb should be transparent. A random link graph will not do. We choose for a strict hierarchy of sections and subsections. Cross links are avoided wherever possible. The actual page position is always indicated in the menu. Checkmarks before completed sections and pages are desirable, but they have not yet been implemented. The problem is: when is a section or page considered completed? Only short detours from the menu are recommended, e.g. from problem to solution (in the subframe), additional info, starting an application, mail client or discussion group.

The material is organized into learning atoms, addressing a more or less self-contained, indivisible unit of study. The explanations, illustrations and exercises in learning atoms are presented as a sequence of pages, each representing a small step in the explanation process. A page contains little text, in favour of images. Between the steps of a sequence there is only forward and backward navigation. Direct links from the menu to a step in the middle are considered unnecessary and undesirable. The approach of dividing the learning material into learning atoms, and limiting the content of a page to a single topic was proposed by Chou [15].

A voice-over is considered helpful [12, 16]. This apparently helps to memorize the information. The opinions of students on this feature, applied in a demo [12], ranged from "annoying" to "useful". There were even suggestions for more sophisticated use of the spoken word. It may be advisable to make the voice-over optional in the future.

Bandwidth

Too much delay is a nuisance. Although transmission speed and bandwidth are growing rapidly, so are the amounts of data to be transfered. A 256-colour image of size 300×200 pixels would have been sufficient eight years ago, but at present a true colour image of size 800×600 pixels is often required. A simple animation no longer suffices, a streaming video clip should be supplied. The inclusion of large multimedia files cannot be avoided, but the needs of users with low-end equipment must be taken into account.

The solution is to supply large files in the ecb on cd-rom, to be distributed along the traditional channels, provided that the material is not subject to rapid change. This is mostly the case, because the production of detailed images and multimedia is time consuming and costly.

However, letting the user search the components on the cd-rom causes inconvenience. Instead, a direct link should be provided from the ecb, preferably in a transparent way, not distinguishing web material and local material. In our model a seamless integration of both sources was achieved. The location of the cd-rom drive must be indicated by the user only once, thereafter every reference from the menu is handled automatically. This has been accomplished with a JavaScript code fragment, using cookies.

Overhead

Earlier versions of the Java demo [17] with a flexible menu led to considerable overhead: each version (with different parts collapsed or expanded) of the menu had to be created separately, by hand. When the actual page was to be highlighted in the menu to indicate the reading position, it turned out to be necessary to create a separate menu page and a frame set for each page.

The introduction of a tree menu applet was a significant improvement. However, the complete menu structure still had to be created and updated manually, in an ASCII input file, which easily resulted in incompatibilities. In the final version a tool was introduced to automatically generate the menu structure from the directory structure. Provided that the authors use a sophisticated html editor, the overhead in generating an electronic book with this version does not exceed the overhead for making a normal text book, if the electronic book only contains text, images, tables, exercises and solutions. The authors just have to follow simple rules for structuring their document collection into directories and subdirectories, in one-to-one correspondence with the desired structure of the menu, and they should in addition adhere to simple naming conventions for the document files.

Admittedly, realising a completely interactive product takes more time, but then again, such features are not supported in traditional text books. The latest version of the Java demo is not yet really interactive. Our inquiries pointed out that some students had expected and hoped for more interaction. Yet the demo was still considered a useful supplement to the printed material of the original course. It remains to be seen how a complete course on the web will be judged.

Dislike for on-screen learning

The results of our inquiries amongst students and experts showed a natural resistance against reading from a computer screen. Within the next decade, when a new generation of students brought up with the computer from early childhood appears, it is plausible that the problem will be less prominent. In the mean time, the effect has to be dealt with.

Our strategy has been to make the advantages of web learning more apparent, and to increase the attractiveness of web based courses. This would be achieved by including images, animations, demonstrations such as simulations, video and sound in the web pages. Additionally, the students would be given the opportunity to experiment, and find out things for themselves, by carrying out small interactive exercises and assignments, fully exploiting the capabilities of modern computers. This corresponds to the paradigm of

"Learning by doing". The same approach has been advocated by other groups [18, 19].

It is recognized that this strategy conflicts with the solution to the previous problem insofar that the inclusion of the elements mentioned implies the investment of a lot of time. To say the least, each text book has to be completely rethought and remodeled in order to serve as an acceptable ecb. The production of such ecb's remains the great challenge for years to come.

Comprehensibility and interest

As screen sizes, resolutions and refresh rates increase and computer displays become more manageable, leading to an improved reading position, the problem is expected to loose significance. Apart from the limitations of monitors, there appears to be no special reason why reading from a screen should be more cumbersome than reading exactly the same text on paper. In the mean time, much could be gained by restructuring the text in traditional text books, usually consisting of large pieces of text, into short bits of textual information, interleaved with visual information, exercises and small assignments.

Student feedback to the demo's included remarks on the readability of the texts. Hence it is important to carefully choose the font face (we used Verdana) and the point size.

Cost of being on line

In time, the cost of being on line will be of less importance, because there is a tendency towards permanent Internet connections, by cable or ADSL. For students that do not have such a connection it may be convenient to load several pages into the browser cache in advance, and then disconnect. This will only be possible if no server side processing of the pages is required, as is the case in Edubox® [6], the future electronic learning environment of the Open University of the Netherlands. Our model does not rely on server side processing; all processing is handled locally.

An alternative solution would be to make complete sections available for downloading to a local hard disk, enabling local viewing of the ecb. Even more convenient for the students would be to distribute the ecb on cd-rom. In our model this works just as well. The only reasons to avoid this would be that actualization is more difficult, and it requires an infrastructure for ordinary mailings.

THE MODEL

In the fall of 2000 we presented a working model, ready for the development of actual courses. The model includes a number of templates for web documents, a frame set, a tree menu applet, a tool to generate the menu structure, and an extensive on line manual [20] with directions on how to use the model, as well as guidelines for designing a course web. The manual is itself structured as a web based course, using the model.

The model is intended as an intermediate stage between the traditional distribution of printed courses and the university wide introduction of the newly developed electronic learning environment Edubox®. This environment is still in its pilot phase, and it is expected that its universal introduction will take one or two years, because further improvements and adaptations in the work flow are required, and a lot of internal training. On the other hand, our model has a low threshold, requires no special equipment, the changes in the work flow are minimal, and one or two days of training suffice for course developers to successfully apply it.

At the moment four course developers are using the model to design new courses or to review existing courses in print. Their experiences so far are promising. By the end of the summer these courses will be published, and, like all new courses, they will be evaluated after the first run. In January 2002 we expect to get ample student feedback on the model.

DESIGNING A WEB BASED COURSE

We conclude this paper with a summary of the steps required to publish an ecb.

First one has to choose a didactical paradigm, e.g. traditional education, competence learning, or problem driven learning. If group activities or contacts with teachers are needed, some form of groupware, or a newsgroup and e-mail addresses must be installed. A choice has to be made for some form of assessment: for instance an exam, an assignment, or peer assessment. All of these forms could be included in the ecb.

Next, the course is divided into small learning atoms. Depending on the didactical paradigm, these may be learning activities or knowledge units, which are grouped into competence levels and sublevels, or sections and subsections, essentially defining the structure of the course. Then the menu tree is designed, in one-to-one correspondence to the grouping, and, in turn, web directories and web documents are created in one-to-one correspondence with the menu structure. The file names of the documents should be in a specific menu format. This format contains the menu title, prefixed with a numerical code to indicate the order in the menu and the type of the document. Special link files can be included to handle links to external web sites, news group or e-mail. Additional material, such as multimedia, designed by experts, may be placed in the various directories. All files with names that do not conform to the menu format will not be displayed in the menu, but can be linked to directly from the text.

Finally, the texts for the web documents are written, according to the guidelines in the ECB web manual [20]. The authors can maintain a glossary on the fly, and insert links to the words in the glossary. After completing the web site the menu structure can be generated using the so-called preorder tool, and the web can be published.

CONCLUSIONS

The Internet generation seems to be ready for the transition to web learning, and all the tools to achieve this are widely available. However, many attempts to make this step forward have failed or turned out to be disappointing in some way. We still believe that the problems associated with web based learning, inhibiting acceptance, can be overcome, but traditional courses from text books would have to be completely remodeled to achieve this. They should meet entirely different requirements. For instance, large pieces of text should be broken up into small fragments, illustrated with visual material, interleaved with exercises and interactive experiments, and/or supported by audio. Smart navigation and an economic use of the screen is considered crucial. Additionally, for the time being, support for cd-rom integration is necessary.

The ecb model, presented in this paper, identifies the problems of web learning, and intends to contribute to finding practical solutions. Whether our solutions are as effective as intended, will become clear after evaluation of the first real web courses, developed while using the model.

Note that we do not advocate the point of view that *all* courseware should be brought into electronic form, to be studied on screen. For many topics printed material remains the perfect medium for study. For many others some media mix may be the best way to transfer knowledge and competencies.

In a year or two the electronic learning environment of the Open University of the Netherlands will be superseded by the Edubox® environment, which has its own support for web based courses. It is unlikely that ecb's developed in our model can be automatically transformed into the format of the Edubox environment, based on the Educational Modeling Language (EML [6]). Still, the principles of our model can be used to structure web courses in Edubox as well. In fact, the authors of this paper are engaged in a project, in which a part of an existing printed course is to be coded into EML. It is also expected that the experiences with the ECB model could be used in later versions of the Edubox system.

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