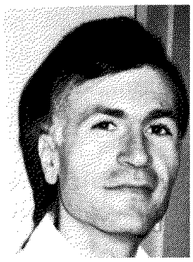
Advanced Educational Uses of the World-Wide Web



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Abstract:

Because of its characteristics, educational uses of WWW can evolve along two major axes: use of the technology on a closed corpus of educational material, for the hypermedia and distance delivery capabilities of the web, on one hand, and use of this technology on an organized structure of links for an open corpus of material that was not necessarily meant for educational use, but which can be "redirected" and exploited in guided educational explorations. These two axes are not antagonistic but can be alternatively or complementarily exploited.

In this paper, we analyze those features of WWW that are most interesting for educational purposes, and show possible sophisticated pedagogical uses of the web.

Keywords:

WWW, Education, Teaching, Computer based teaching, Computer based learning, Distance learning, Open learning.

1. Introduction

Tools such as Gopher[1] and WWW[2] [tbl94] have been developed largely to facilitate sharing of technical and corporate information at colleges, universities and research institutions. But very quickly, potential educational applications of these technologies became apparent, especially for open and distance learning. In this regard, WWW has more appeal, because of its hypermedia foundation. Its use is growing very rapidly, and it can now be used to access an immense volume of rapidly evolving information. Thus, another strength of WWW is its access to the latest version of a document. Because of all these characteristics, pedagogical uses of the web can evolve along two major axes:

1) use of the technology on a closed corpus of educational material, for the hypermedia and distance delivery capabilities of the web, on one hand, and

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1. gopher://gopher.micro.umn.edu/11/Information%20About%20Gopher
2. http://info.cern.ch/

2) use of this technology on an organized structure of links for an open corpus of material that was not necessarily meant initially for pedagogical use, but which can be "redirected" and exploited in guided educational explorations.

These two axes are not antagonistic but can be alternatively or complementarily followed.

Long before WWW had reached wide acceptance, the Internet was being used for educational purposes[1], mostly via mailing lists and bulletin boards. In spite of its tremendous growth, WWW is still only marginally used for educational purposes, probably even more so in Europe where very few primary and secondary schools have access to the Internet. In this regard, WWW is acting as a driving force, since its ease of use makes the Internet[2] trivially accessible to pupils with no prior knowledge of computers, programming or even networking, making it more tempting for teachers to take advantage of it.

This access by young pupils to the Internet raises some issues, both ethical and technical: can one allow minors free use of a facility that can potentially give them access to pornographic material? or that makes it very easy for them to pull huge amounts of data accross long distances without their realizing the costs and consequences of their actions? Should one therefore limit their access to the Internet to class work, where a teacher can ensure they are not misusing the facility?

2. Educationally attractive WWW features

Needless to say that the first features that come to mind are:

• the ability to have multimedia documents [sch94],
• the hypertext/hypermedia capability [bus45],
• WWW networked basis, allowing for distance learning,

Of course, the availability of public-domain client[3] and server[4] software for many different platforms, the relative simplicity of the HTML syntax[5] and the availability of free editing tools[6] are also essential elements to the interest that school teachers find in the WWW.

These features and their attractiveness, for education in general, as well as for distance learning, have already been discussed at length in the past and will therefore not be discussed any further in this paper.

A new feature that has been added recently to HTML[7] is the possibility to include, in a document, input fields that the reader can fill out and the contents of which will be transmitted when the reader pushes a "submit" button. This fill-out form[8] capability has been essential in

1. http://www.eff.org/papers/eegtti/eeg_241.html#SEC242
2. http://www.eff.org/papers/eegtti/eegtti.html
3. http://info.cern.ch/hypertext/WWW/Clients
4. http://info.cern.ch/hypertext/WWW/Daemon/Overview.html
5. http://www.hal.com/users/connolly/html-spec/spyglass-19941014/HTMLSPEC_1.html
6. http://info.cern.ch/hypertext/WWW/Tools/Overview.html
7. http://www.ncsa.uiuc.edu/demoweb/html-primer.html
8. http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/Docs/fill-out-forms/overview.html

allowing new uses of the web, where the user can be more active than just clicking on sensitive areas of a document.

One potential difficulty for teachers in using forms to create "interactive" documents is that the use of forms requires some programming on the server to handle the requests (generated by the forms these teachers would like to include in their WWW-based courses) and process the information entered by the user. As a help to people who are not knowledgeable about cgi[1]-bin scripts programming, one can find CGI-compliant programs (e.g. the Zot-Dispatch[2] automatic form handling script generator, available from the University of California, Irvine[3]) that will automatically generate the cgi-bin script appropriate to handle the results sent via a form. Unfortunately, these tools are not always general enough to allow sophisticated handling of the information provided by the user. They typically allow field substitution in a template document that will either be emailed to an address or list of addresses, or sent back to the user, or appended to a file. Some have gone further than this, developing tools to automatically convert applications with GUIs to fill-out forms coupled with cgi-bin programs [thr94].

In an advanced educational setting, one will want more complex handling. For instance, we[4] are currently working on the design of a tool that will allow teachers to not only specify interactively their forms via a regular WWW viewer, but also specify, with a symbolic formalism, free-text answer analysis criteria that will be applied to some user-entered form fields to select appropriate response documents, in addition to modifying these response documents on-the-fly, based on some other user-entered form fields as well. This tool will also generate automatically the cgi-bin scripts that will handle the information sent via the forms, and possibly pass that information via sockets to programs that would be running on the WWW server, a mechanism we have used in a former project[5], in which we allowed students to control remotely, via WWW, example programs that were described in their Data Structure class.

Another, even more recent, feature that is of interest in an educational setting is the ability to run a WWW viewer in "kiosk mode"[6], by which the browsing can be limited to some specific set of documents. This is obviously one way to solve the problem of giving pupils access to the Internet without having to fear questionable uses that could provide arguments to those people who are opposed to giving Internet access to schools under the pretext that it would give minors uncontrolled access to pornographic or violence-related documents, while the school is paying for these resources.

3. Use of WWW for pedagogical purposes

Just browsing through the web is already an educational experience in itself. Many people have lived this phenomenon by which they start browsing through the web with something specific in mind and end up diverted from their initial goal for a while because they found something interesting on the way, that they were not explicitly looking for. This is what one could call

1. http://hoohoo.ncsa.uiuc.edu/cgi/
2. http://www.uci.edu/X/W6/forms/zot-dispatch/ZD-Doc.html
3. http://www.uci.edu/
4. http://cui_www.unige.ch/eao/www/readme.html
5. http://cui_www.unige.ch/eao/www/WWW94/paper.html
6. http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/Docs/help-on-version-2.5b.html

"accidental learning", that is, learning that happens at an unexpected moment, about an unexpected subject.

There are however structured ways[1] in which WWW can be used for education. Two main approaches come to mind: on one hand, using the technology on a closed corpus of educational material, mostly for the hypermedia and distance delivery capabilities of WWW and, on the other hand, using the technology to access, in a structured way, an open corpus of material that was not necessarily meant initially to be used for specific educational purposes.

3.1. Closed corpus

In this first category one can often find "hyper-courses" that take advantage of WWW's hypertext capabilities. This, combined with the fill-out form capability, can allow courseware designers to create educational material that has most of the characteristics of regular courseware that runs on a stand-alone machine, with the additional advantage of being easily accessible from remote locations.

One characteristic of WWW that can appear as a limitation is the fact that the HTTP protocol[2] is stateless, that is, there is no direct relationship of any kind between two consecutive requests to the same server, even if the queries come from the same user. The server treats every request it receives independently from any other request it received in the past or that it will receive in the future. This statelessness allows the HTTP server software to impose very little overhead on the server machine, and keeps the protocol between the client and server very simple.

However, good educational material should take into account the background of each learner to tailor its behavior to the learner's capabilities and past history, and to provide appropriate remediation to learners who experience difficulties with some concepts. To achieve this, the educational software has to keep track of the users' states and actions, which seems to contradict the statelessness of WWW. The solution we developed to overcome this difficulty has been to combine the fill-out form capability with the possibility for the HTTP server to execute external programs or shell scripts in response to a request.

Normally, when the HTTP server executes an external program or shell script, it waits until the program is finished to send the program's output as a virtual HTML document. In our case[3] [ibr94], to maintain a state between consecutive requests, the external shell script spawns a child process that will continue executing during the whole educational sequence. The output of the child process is passed to the HTTP server as a virtual HTML document. The hyper-links embedded in this document contain the process Id of the child process. With this information, the shell script invoked by the HTTP server on a later request can reconnect to the spawned child process and pass it the rest of the request data that will contain information provided by the learner. This mechanism is described in Fig. 1.

The approach we have just described has its advantages and its drawbacks. Among the advantages we find the portability achieved by using HTML for the spawned process output.

1. For some structured documents on WWW and education, see "The World Lecture Hall" (maintained at the University of Texas, Austin), and the Second World Wide Web Conference '94, papers on Education.
2. http://www.w3.org/hypertext/WWW/Protocols/HTTP/HTTP2.html
3. http://cui_www.unige.ch/eao/www/WWW94/paper.html

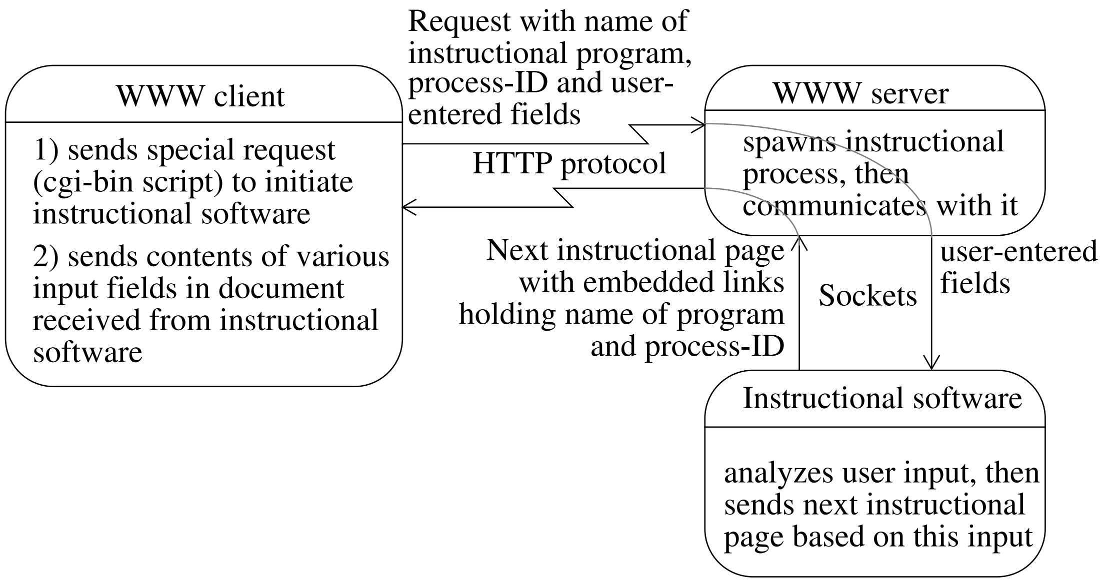

Fig. 1: Interaction scheme between the remote user and some instructional software via WWW.

Whatever the machine the user is working on, the viewer should be able to handle HTML documents and thus be able to display the output of the educational process, regardless of the hardware of the machine. There is therefore only one executable version of the courseware, that resides on the server machine. As a consequence, anybody can engage very simply in the educational process, from anywhere in the (Internet) world, at any time, without any bootstrapping procedure. One drawback is that this server machine can become overloaded and thus unable to serve new users. Another drawback is that the user interactions and the program output are limited by the HTML syntax.

Another approach to the closed corpus option is to define a new document type and have a special dedicated viewer handle the "document" sent by the HTTP server. This viewer can be an interpreter for some special purpose language and it will use the document sent by the server as a program to interpret/execute on the client machine, thus removing the load from the server. This external viewer can send a specific system signal to the main WWW viewer to tell it to display a new document, the URL of which has been put in a temporary file[1]. When used in combination with fill-out forms, this allows bidirectional communication between the main WWW viewer and the external viewer that are both running on the same client machine[2]. A more effective scheme is currently being proposed as a Client Communication Interface[3] (CCI) protocol, that should allow bidirectional communication between a WWW viewer and an external application, without necessarily transiting throught a WWW server.

The main advantage of this approach is that it can potentially use all the graphical and computational capabilities of the client machine, thus resulting in more powerful user interfaces and faster response times. The drawbacks are that one needs to have a dedicated viewer on the

1. http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/Docs/remote-control.html
2. http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/Educ/smeaton/ise_www/ise_www94.html
3. http://yahoo.ncsa.uiuc.edu/mosaic/cci.spec

client machine (this viewer has to be downloaded by the users/learners before they can start the educational process, or it has to be pre-installed by the teacher or the local system manager) and that a different executable version of the interpreter has to be produced for every different kind of hardware that the learners can potentially use. Another possible drawback could be related to security issues if the interpreter can potentially execute instructions that would harm the local computer environment (software viruses).

3.2. Open corpus

The other approach to educational use of the web is to exploit the enormous amount of information that is accessible via the Internet, whether it has been put there for educational purposes or not. It is the author's belief that nobody yet has been able to evaluate, even very approximately, the volume of information that is now available to every Internet user. From the statistics of the NSFNet backbone traffic[1], one could conjecture that this volume is likely to be in the order of magnitude of thousands of billions of characters (terabytes).

Given its gigantic size, this ocean of information has to be harnessed to make it manageable and useful to users and learners. In this regard, WWW appears to be very useful in that its network-based hypertextual capabilities make it very appropriate to organize into a hierarchy this huge volume. CERN[2] has started a very interesting project called the WWW Virtual Library[3]. Its purpose is to create a distributed catalogue of all the Internet resources accessible via WWW. It is maintained on a voluntary basis by people who are specialists in a specific domain and who are willing to share and maintain a document, or a hierarchy of documents, that reflect a certain structure of their domain, giving access to all the major Internet-accessible resources that they are aware of. The subjects of the WWW Virtual Library range over a very wide spectrum, covering most regular subjects of study, as well as recreational subjects or more esoteric ones like "Paranormal Phenomena"[4] or UFOs[5].

Electronic journals and online magazines[6] also constitute interesting sources of information that are probably going to develop and grow as people get more accustomed to the electronic media.

As useful as they may be for researchers or post-graduate students, these structuring resources are probably not directly usable as is for more basic educational purposes. They are nevertheless a good example of what can be done to present a subject to people who want to learn about it. One can easily imagine developing more elaborate structural documents that will guide learners in their exploration of a subject domain. The educational material would thus consist of a combination of explanatory text, pointers to more in-depth material publicly available on the Internet and, possibly, some features of the closed corpus approach by which the learner could be evaluated and proposed complementary or remedial material.

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1. ftp://nic.merit.edu/nsfnet/statistics/
2. Centre Européen de Recherche Nucléaire (European Center for Nuclear Research) http://www.cern.ch/ birthplace of the World-Wide Web.
3. http://info.cern.ch/hypertext/DataSources/bySubject/Overview.html
4. http://www.declab.usu.edu:8080/X/
5. http://www.bgsu.edu/~jzawodn/ufo/
6. http://info.cern.ch/hypertext/DataSources/bySubject/Electronic_Journals.html

An interesting pedagogical strategy [wra94] one can use in the open corpus approach is to have pupils use WWW in their process of knowledge appropriation[1] by giving them the task to create their own documents that will tie together the information they have collected in a more constructive way than just enumerate pointers to existing documents[2]. These synthetic documents (in the sense of documents synthesizing the content of other documents) created by pupils can also help the teacher have a better grasp of the pupils' mental structures. Even more important, the pupils' documents can help the teacher offer appropriate remediation to those pupils who have not been able to go far enough in their discovery of a subject.

4. Conclusion

In this paper, we have first presented an overview of the capabilities of the World-Wide Web, then we presented two complementary strategies that can be deployed to develop educational material that makes use of these capabilities. The first strategy resembles more the traditional distance learning approach and focuses on using the hypertextual and remote access facilities of WWW, while the second strategy is more oriented towards open learning and focuses on using all the information accessible on the Internet. The combination of the two strategies looks very promising and should lead to the creation of educational material that has no equivalent in any other medium.

However, for this to happen, there is a need for appropriate tools that will make it much easier for teachers to integrate forms in their hyperdocuments and produce the corresponding cgi-bin scripts and programs to handle the data collected with these forms.

As for the ethical and technical issues that are raised by having youngsters gain potential access to "undesirable" documents or pull huge amounts of data over long distances, we have shown that technical solutions existed that should reassure educators and allow them to give their pupils open but not unlimited access to the Internet, even outside the classroom. The kiosk mode[3] makes it possible to limit the access to a more or less controlled set of documents, making it virtually impossible to reach those servers that distribute offending documents.

The problem of excessive network traffic could be resolved in the same way, but limiting the access to servers that provide only "reasonably sized" documents is probably too drastic. Ideally, the WWW viewers should include the possibility to limit the size of the documents that can be retrieved. The HTTP protocol[4] allows it already, since a WWW client can use the HEAD request method to get, among other information, the size of a document. The authors are however not aware of any WWW viewer that implements such a capability.

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1. By knowledge appropriation we mean the process by which the learners structure the information according to their own points of view to integrate it with the rest of their knowledge. Having to create their own documents to tie together the various pieces of information they have collected all over the Internet can force pupils to think about the interrelationships that can exist among these pieces and between these pieces and the elements of their own knowledge and mental structures.
2. Since most WWW viewers allow the user to open local documents without the need for an HTTP server to be running on the user's machine, a teacher doesn't need to have a local server to have pupils create their own documents that are "connected" to other documents worldwide.
3. http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/Docs/help-on-version-2.5b.html
4. http://www.w3.org/hypertext/WWW/Protocols/HTTP/HTTP2.html

Bibliography

[bus45]Vannevar Bush;
"As we may think";
Atlantic Magazine, July 1945,
http://www.csi.uottawa.ca/~dduchier/misc/vbush/as-we-may-think.html

[ibr94] Bertrand Ibrahim;
"World-Wide Algorithm Animation";
in Computer Networks and ISDN Systems, Vol. 27, No. 2, Nov. 1994, Special Issue, Selected Papers of the First World-Wide Web Conference, pp 255-265,
http://cuiwww.unige.ch/eao/www/WWW94/paper.html, also accessible via
http://www.elsevier.nl/cgi-bin/query/WWW94/FinalProgramme.html?ibrahim
and http://www1.cern.ch/PapersWWW94/bertrand.ps

[sch94]Bruce R. Schatz, Joseph B. Hardin;
"NCSA Mosaic and the World Wide Web: Global Hypermedia Protocols for the Internet";
in Science, Vol. 265, 12 Aug. 1994, pp 895-901.

[tbl94]Tim Berners-Lee, Robert Cailliau, Ari Luotonen, Henrik Frystyk Nielsen, Arthur Secret;
"The World-Wide Web";
in Communications of the ACM, Vol. 37, No. 8, Aug. 1994, pp 76-82.

[thr94] Robert K. Thralls; "Building HTML Application Systems: Converting Existing MS-Windows Applications to HTML"; in Electronic Proceedings of the Second International WWW Conference '94: Mosaic and the Web[1], Chicago, Oct. 17-20, 1994,
http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/WebProd/thralls/WhitePaper.html

[wra94]Robert E. Wray, III, Ronald Chong, Joseph Phillips, Seth Rogers, William Walsh, John Laird; "Organizing Information in Mosaic: A Classroom Experiment"; in Electronic Proceedings of the Second International WWW Conference '94: Mosaic and the Web, Chicago, Oct. 17-20, 1994.
http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/Educ/wray/wrayre-experiment-mosaic94.html

1. http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/WWW2_Proceedings.html