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Evaluating and Improving WWW-Aided Instruction

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Abstract: A growing number of instructors are putting course resources on the World Wide Web (WWW) [Berners-Lee et al. 1994], from simple course descriptions through traditional printed handouts to complete „classroom-free“ classes ([Team Web 1995] provides a broad sampling of such resources). However, there appears to be a paucity of evaluation of WWW-based classroom resources. Do they help or do they hurt? Which materials are more valuable or less valuable? How do students react to the web?

This paper describes the design, evaluation, redesign, and re-evaluation of a number of course webs that incorporate a wide range of resources (including readings, notes, transcriptions, and traditional handouts) and media (including text, images, and audio). This paper generalizes student reactions to webs for two introductory Computer Science courses [Rebelsky 1994] [Rebelsky 1996], incorporating additional comments from students in advanced courses.

Key Words: Multimedia Information Systems [Evaluation/Methodology], Computer Uses in Education, World-Wide Web, Hypertext Document Design and Preparation, Computer Science Education, Computer Literacy.

Categories: K.3.1, H.5.1, I.7.2, K.3.2, K.3.m

1 Introduction

Hypermedia is beginning to change the way we think, teach, and learn. While sophisticated hypermedia applications, such as Perseus [Marchionini and Crane 1994] [Crane 1995] provide the promise of new learning and teaching strategies, a simpler and quieter hypermedia teaching revolution is upon us: the use of the World Wide Web for providing course resources. The University of Texas at Austin World Lecture Hall [Team Web 1995] presents resources from hundreds of online courses in dozens of disciplines. In spite of the vast array of electronic courses, there seems to be little formal or informal evaluation of WWW-aided instruction, other than short notes, such as [Windley 1994].

There are a number of questions that might be asked about the design and implementation of course-based webs. These include

- *What is the relationship between the WWW resources and the course as a whole?* Some webs simply reproduce printed handouts; some treat the WWW as a presentation medium for overheads akin to PowerPoint; still others provide additional materials that students would not otherwise receive, such as hints and collections of questions and answers. Most webs are intended only as a course supplement, although a growing

number are intended as replacements for traditional classroom-based learning.

- *What materials does the web include, and why?* Some courses provide only homework assignments and a few informational handouts; others provide enough materials to support a complete „classroom-free" course, in which students can attend only through the web.
- *How is the web created?* Some use automatic conversion programs to convert preexisting materials; others completely redevelop materials to take advantage of the additional capabilities of hypertext. When creating materials anew, one may use a text editor, a WYSIWYG system, like PageMill [Adobe 1995], or a site-level editor, like ASML [Frank et al. 1996] or CourseWeaver [Rebelsky 1997].
- *How are the materials organized?* Some webs are little more than collections of documents with a hierarchical table of contents. Others illustrate more complex relationships.
- *How are the materials segmented and presented?* While good hypertext design [Berners-Lee 1994] suggests small nodes, many course webs might provide longer documents that facilitate printing, as students tend to print materials [Mook 1994] [Rebelsky 1994] [Windley 1994]. It is also possible to provide multiple „views" of the same material.
- *What software supports the web?* For example, is a search engine or intelligent aide included? Is it possible to automatically reconfigure the web (e.g., to provide the multiple „views" mentioned above)?

Perhaps more importantly, questions need to be asked about the effects of course-based webs. In particular, *Does the web of materials help students learn, or hinder learning?* However, this question is broad enough that it is helpful to consider more specific effects on usage and learning.

- *What materials do students use, and why?* There is little point to creating a web (or a particular component) if students do not use it.
- *How do students react to the array of materials presented?* Are they overwhelmed by the number of materials available, or are they able to select only the appropriate materials?
- *Can students navigate the web?* Frequently, users get „lost in hyperspace" [Nielsen 1995]. Does the scope or design of a course web make it easier for students to quickly find the materials they need?
- *Do some use the materials as an excuse to miss lectures or discussions?*
- An extensive collection of resources might lead students to stop taking notes. *Do webs affect student note-taking?* If so, what types of notes do they still take? Does it permit them to participate more actively?
- An implied reason for creating webs is that we expect reuse of materials. *Do students and instructors reuse past materials?* If so, how?

In a number of courses, I have investigated possible ways of using the World-Wide Web to provide a variety of resources for courses in Computer Science and of evaluating the effects of those resources on student learning. In [Rebelsky 1994], I reported on the initial design and development of an extensive course web for an

introductory Computer Science course and the student reactions to that web. In [Rebelsky 1996], I reported on the redesign of that course web to incorporate the results of the first study and on the student reactions to the redesign. In this paper, I describe common results, key ideas, and evaluation strategies from the two studies, extended by student reactions to a similar web in an advanced Computer Science course on networking.

2 Background

2.1 Subjects and Setting

Dartmouth's COSC004 — Concepts in Computing — is one of the new type of introductory courses designed for nonmajors that present an introduction to the field of Computer Science, rather than to only computer applications, computer concepts, or computer programming. The students in this course are generally humanists between their second and third year of college — in 1994, 25 such students participated in the course and survey; in 1995, 31 such students participated. The course touches on a number of topics, including hypermedia, algorithm design and analysis, language design, theoretical Computer Science, computer programming, computer architecture, and implications of computing. Students read not only a standard textbook [Schneider and Gersting 1995], but also a number of source materials, such as [Bush 1945]. In addition, they complete a number of lengthy assignments as well as weekly laboratories and infrequent tasks. Many students also complete a course project that incorporates key algorithms, hypermedia, information retrieval, and interface design.

The amount of material in the course makes it one of the most work-intensive courses the students encounter. In end-of-course surveys, over 90% of the students in the course regularly report that it is „much more work than the average course“ (the highest ranking available in response to the question), with the remaining 10% reporting that it is „more work than the average course.“ Because of the scope of material covered in the course and the workload, I chose to create a web of resources to better support student learning and accommodate some alternative learning strategies. As such, the web is intended as a *supplement* to, and not a replacement for, classroom-, group-, textbook-, and assignment-based learning.

To provide additional perspective to these results, I have also included results from an advanced undergraduate course in Computer Networking, held in 1996 with 27 students. However, the primary subjects are the students in the introductory courses.

2.2 Resources

In all the studies described in this paper, I experimented with the types and numbers of materials that students would use, as well as the ways that those materials were

distributed. In all cases, webs included traditional materials, such as assignments and syllabus, but also supplemented these materials with a variety of alternate materials, such as transcriptions or course outlines. For both the introductory courses, I used a projected computer display for the course „blackboard," typing on the computer during each class (that is, the blackboards were not prepared before class). For the 1994 course, a custom HyperCard stack provided the blackboard (to better mimic the "uniform board space" one finds in traditional blackboards. For the 1995 course, a text editor provided the blackboard. This method gives a continuous, rather than segmented, view of the material written on the blackboard in each class.

2.2.1 Resources, Phase One (1994)

My main intent in the 1994 course web was to provide as many materials as possible. Hence, in addition to including traditional materials, such as assignments and syllabus, this web also included an outline of each session (prepared in advance and handed out to students at the beginning of the session), the text from the blackboard of each session (to allow students to pay attention to what was happening in lecture or discussion, rather than frantically trying to copy down every word), a transcription of each session (so that students could easily recall something mentioned in discussion or lecture), and a collection of questions and answers. While I had originally hoped to include audio and video clips, limited time prevented the incorporation of such materials. I also asked each student to write a short (1–3 page) guide to a subject of that student's choosing, working under the dual assumptions that students learn by trying to teach, and that peer-written materials could better support student learning [Annis 1983] [Mazur 1993]. In addition, phase one included a number of non-WWW materials, particularly animations built in HyperCard (as in 1994, the WWW did not yet incorporate a programming language).

2.2.2 Resources, Phase Two (1995)

Because students reported feeling overwhelmed by the number of resources in the 1994 web (see [Section 3] below), the redesign of the web for a new session of the course used fewer resources. Because of the exclusively positive reaction to the informal course outlines, I used those outlines as the focus of the new web. Because students invariably print such outlines, I provided them at the beginning of each session (and used a high-level outline at the beginning of each outline to give them a sense of the proposed order of the topics covered that day). I dropped materials, such as transcriptions, that seemed particularly overwhelming. I also added a few types of materials that I had not used in the previous web, such as audio reproductions of the first few classes (which took long enough to prepare that students did not use them).

In the hopes that students would reuse past materials, I included general links to past course materials, including not only the web created for the previous course, but also the student-authored guides and selected student homework assignments. For

this course, instead of asking students to write tutorials, I asked each student to convert a „blackboard“ (created in Microsoft word) to HTML. Finally, this course again used HyperCard-based stacks to provide additional interactivity and/or animations. Hence, the primary resources provided for this course were: syllabus, outlines, assignments and solutions, reproductions of blackboards, selected questions and answers, selected longer instructional guides, and materials from the past course.

2.2.3 Resources, Advanced Course (1996)

Because of time constraints, the course web for the advanced course included many fewer types of materials than the other two courses (although my teaching assistant provided the student with an extensive array to non-local resources on the WWW). Again, course outlines provided the center of this web, but no blackboards or audio materials were available. Assignments, answer keys, syllabus, and selected questions and answers were also part of this course web.

2.2.4 Distribution of Resources

Because a number of resources were used in each course, it also became necessary to use a number of distribution mechanisms along with the web. In part, the form of distribution helped students prioritize materials. Because students in the 1994 course reacted positively to these distribution methods, they were used again in the 1995 course.

- The most important resources were printed and handed out at the beginning of each class. Such resources included the course guide and syllabus, assignments, and the outlines of individual classes. All of these materials were also available on the World-Wide Web.
- Somewhat less-important resources were sent through electronic mail. These included comments on assignments and answers to select questions. Most of these materials were also available on the World-Wide Web.
- Time-critical materials (e.g., corrections to assignments) were also sent through electronic mail. Most of these materials were indirectly incorporated into the web (primarily through modifications to underlying documents).
- Other resources that might only be appropriate for certain types of learners were put on the network and the students were informed of their existence by electronic mail, a mention during the class session, or a pointer in the class notes. These resources included the transcriptions, student notes on topics, and broader collections of questions and answers. Some regularly created resources, such as the electronic blackboards, were mentioned only at the start of the term.

- Macintosh-specific resources, such as HyperCard stacks or the original versions of electronic blackboards (in HyperCard or Microsoft Word format) were placed on an AppleShare server.

2.3 Organization and Support for Navigation

Categories provided the primary organization of pages: each page had a link from a category-specific index (e.g., an index of all assignments) and to the prior and next pages in the same category. Of course, traditional hypertext links provided an additional navigation method (e.g., when an assignment mentioned a topic, it included a link to the outline describing that topic). Students could access materials through the course syllabus, through component-specific indices, from related pages, and by directly entering URLs. The course syllabus included links to each day's notes, to assignments, and to additional handouts (e.g., a tutorial guide to HTML authoring).

In addition, a simple searching engine was provided to facilitate access to materials. For the 1994 course, the search engine was based on WAIS. For the 1995 course, it was based on a custom-authored search engine that provided context in a way that students seemed to prefer. This simpler searching engine, when given a keyword, lists all the documents that contain the keyword along with all the lines in each document that contain the keyword (with the word highlighted). To ensure that students knew about this facility, I gave them a short assignment to use it and compare its interface to that of the traditional search strategy.

The design of individual pages also helped students navigate. Most pages began with a short outline of the page to prepare students for the rest of the page. Such introductory outlines not only support navigation and scanning, they also enhance learning [Krug et al. 1989]. Because I expected that students would occasionally prefer to directly enter URLs, each handout included the URL at the top (Netscape Navigator [Netscape 1996] and other browsers now support printing of URLs, but did not do so at the time).

2.4 Evaluation

It is, of course, difficult to evaluate the success of a teaching method (e.g., [McKeachie 1986, pp. 260-265]). Hence, student reactions and effects on the course instructor were used as the primary evaluation criteria. Student reactions were evaluated both qualitatively and quantitatively.

At the end of each term, students were given a non-anonymous evaluation form to determine their reactions to both the electronic resources for the course and to the various course topics This evaluation was given in addition to the College-wide anonymous evaluation (which targets traditional instructional techniques) and included more specific questions than traditional course evaluation forms. In particular, this evaluation asked the students to comment on many of the components of the web as well as to other issues in the course. Questions on the web were only a

small part of the initial evaluation, but emphasized written answers: of the 52 "check an answer" questions, 13 asked about the course web; of the 16 "written" questions, 8 asked about the course web. Unfortunately, the initial evaluation focused on materials, rather than usage and was redesigned for the 1995 course. While the 1994 evaluation was focused on form and qualitative data, the 1995 evaluation emphasized usage and quantitative data, asking students not only how much they used resources, but also how it changed their learning. For this evaluation, 21 of 55 check-box problems were on the web, and only 5 of 21 written answers.

Although it might have been preferable to conduct the survey using HTML forms, the browser many students used for the 1994 version of the course (NCSA Mosaic for the Mac version 1.03 [NCSA 1993]) did not support forms. While better browsers were available for the 1995 version, a paper version was again used due to time limitations (although some students chose to copy the online version and insert comments). For future courses, a version of [Greenwood and Recker 1996] will be used.

The response rate for this survey was very high. Over 90% of the students in the 1994 class filled out the survey forms and all the students in both the 1995 course and the 1996 (advanced majors) course filled out the form. In addition, students were very open about their answers, feeling free to criticize the course. I believe that this is not only because the students trusted me, but also because of Dartmouth's honor code, which encourages them to answer honestly and me to hold to a promise of reading evaluations only after grades were turned in.

3 Results

Students appeared satisfied with (and even enthusiastic about) the resources provided on the web, and the decision to use the web (as opposed to an AppleShare File Server, for example) to distribute them. Unfortunately, the 1994 survey lacked questions on level or frequency of use, preventing substantial qualitative analysis. Nonetheless, from student reactions to the survey, it was clear that different students used different resources.

In the subsequent experiment, students had generally positive reactions to the use of WWW-based resources. The reorganization and reduction in number of core materials also seemed to encourage online usage — with an average student rating of 3.3 on the question of „How often did you use the WWW-based class materials (1 = never; 5 = all the time)?“ No students in the introductory courses responded 1 for this question, suggesting that all students used the materials at some time. Many were quite enthusiastic, with comment similar to „I hope you don't discontinue this — I think these [WWW-based materials] are a very handy reference if you need to go back and search or whatever.“

Students in the introductory courses generally found the number of online materials and electronic handouts overwhelming. For example, one student in the 1994 course reported

> *With so much time available, it is essential to limit the resources we will use or we will never finish any assignment. At times, I felt guilty for not conscientiously printing out transcripts, blackboards, etc., etc. However, to use all the resources would lead to being at your computer 24 hours a day.*

Even in the less resource-intensive web created for the 1995 course, over half of the students still found the number of online materials and electronic handouts overwhelming. As the quotation above suggests, this sense of being overwhelmed may be due in part to the workload in the course. As suggested earlier, most students find that this course requires much more work than the average course. In addition, many are stunned to discover that the breadth-first approach means that the touch on topics (e.g., the halting problem) that their colleagues who are Computer Science majors do not touch on until their senior year. This discovery may indirectly enhance the sense of being overwhelmed. Reactions to the majors-only course (which, admittedly, provides fewer resources) support this notion. In the majors only course, no student reported being overwhelmed by the materials.

The use of a search engine was not successful in the 1994 course, with only 13% reporting that they used it to find documents. In part, this was due to the engine itself; students sometimes searched for text that appeared in raw HTML but not on the page, and were confused by the results. Others were confused that the „summary" given to them (the first few lines of the document) did not include the text. In addition, the search mechanism was only mentioned at the beginning of the term, and not mentioned later in the term. The revised searching engine and increased emphasis on searching seem to have paid off: 63% of the students reported that they used the new search utility. This is a significant increase over the previous course. It is likely that the reduction in number of new materials and the availability of past materials gave students further incentive to use the search feature. From informal student notes written directly on the survey, it appears that searching is not a study or retrieval technique they use regularly. Rather, it is a technique that they use occasionally, perhaps when other techniques fail.

A small percentage of students (4% in 1994, 10% in 1995) reported that they used the availability of electronic course materials as an excuse to miss lectures and discussions. It is difficult to assess how much the materials contributed to these absences, as there is always a select population of students who prefer not to attend sessions. For example, in the advanced class no students reported using the materials as an excuse to miss class, although there was a small group who attended very few classes. It is also pleasing to note that at least one student in the 1995 class wanted to ensure that the web would not suffer because of the absentee students. This student reported „Those who miss class because of the WWW materials are only hurting their own knowledge, because *much* more goes on in class than you can get from the Web pages." Others noted that the materials were not necessarily an appropriate substitute. One stated, „The blackboards were good review for a class that I had been to, but not one that I'd missed — I don't think I would change that."

One intent of the use of WWW resources and electronic blackboards was to change student note-taking activities so that they spent more time paying attention to ideas and topics, and less copying down whatever I wrote on the blackboard. This

attempt was successful, in that 93% reported that the resources did change their note taking habits. Unfortunately, the change was not necessarily positive. Although the overall average in response to a question in the 1995 evaluation on the affect of changing note-taking on learning was 3.1 (with 1 being highly negative, 3 being no change, and 5 being highly positive), 37% reported a negative effect on their learning.

There were a wide variety of opinions on the usefulness of the electronic blackboards. In the 1994 class, all students responding to the question indicated that they used the HyperCard versions of the blackboards, but only 17% reported using the HTML versions of the blackboards. While the average usefulness rating was high in both classes (3.78/5.0 in the 1994 class; 3.6/5.0 in the 1995 class) and 24% of the students in the 1995 class selected the highest possible rating, 17% of the students in the 1995 gave the blackboards a negative rating. Surprisingly, some students found this simple technique quite revolutionary, with one writing „I think that the blackboards were a *great* and *innovative* idea. Everyone talks about computers in the classroom — in this class, we actually got it.“ Another indicated that my intent to change their habits had been successful, writing „I thought this was very handy, as it left us freer to think and talk in class.“ However, there were apparent disadvantages for some students. This same student also wrote, „Maybe we (I?) became too dependent on it [the electronic blackboard], though, because many times I would go back and have no idea what they meant.“ Another noted, „I learn better when I take my own notes.“

While I had hoped that students would avail themselves of materials from the previous course, most (66%) made no use of past materials. Of those that did, the primary use was to look at past student homework assignments for ideas in new homework assignments. However, 93% reported that they felt that there were general benefits to having resources from past classes available online. These results are similar to those from the previous course, in which 33% reported that they would have used resources from past classes had they been available (and another 43% said that they might take advantage of such resources, depending on needs). One student who objected to the past materials noted that they were somewhat misleading, as the course had changed from the previous session to the current session.

4 Discussion

The responses described above, in conjunction with responses from the past course and informal discussions with students make it possible to answer many of the questions posed at the start of this paper.

What materials do students use? They seem to use almost anything that is made available. This means that they can easily be overwhelmed by the materials. They are clearly still at the stage in their learning development in which they need some guidance as to which materials to use or to avoid. Instructors can provide this guidance by reducing the number of key materials they use (particularly to short notes or outlines) and by clearly designating secondary materials. In this instance, the materials from past courses could have added to the confusion for students, but the

separation of those materials should be a benefit rather than a detraction. Instructors can also aid students by providing clear trails [Bush 1945] through the web and by organizing the web so that a student interested in reviewing (or learning) about a topic will know precisely which sequence of documents is most likely to help. As [Lanza and Roselli 1991] suggest, while some students benefit from the non-linearity of hypertexts, others are better served by a fixed, linear lesson plan.

How do students react to the array of materials? In general, they react positively. As many of us have seen, students tend to appreciate any extra effort that is devoted to the course. A simple web, with obvious paths, seems to prevent the chance of students getting lost. A smaller web also ameliorates negative reactions to a sense of overload.

How do students navigate through the web? Somewhat naively, it seems. Most seemed only willing to follow links on pages instead of using a search engine or typing in expected URLs (e.g., a student without the outline of class 11 should be able to guess that its URL relative to the root of the course hypertext is Outlines/outline.11.html). Unfortunately, I would occasionally receive reports that a page was not available online, when it was available, but I had neglected to add it to the appropriate index.

Finally, students were generally enthusiastic to having access to questions from other students (and corresponding answers from teacher or teaching assistants). One reported, „The 'recent questions and their answers' from other students really helped. Often you have a similar question, but don't feel like asking 10,000 questions." However, the way in which the questions were distributed did not seem to matter. For both courses, I often sent questions and answers by electronic mail, rather than putting them on the web (mostly due to time constraints), and students seemed satisfied by this. At the same time, some questions were better answered with web pages, and students were also happy with them.

The results on effect of learning also appear less positive. While the WWW-based materials clearly aided some students, they also had negative effects on other students. Again, this is an instance in which instructor guidance can ameliorate the negative effects. Students need to be reminded that there are a variety of learning styles, and while some may learn better by „thinking rather than writing," others need to take notes in order to cement ideas in their mind [Carrier 1983] It is important to help students learn how to take notes in conjunction with electronic blackboards and class outlines, and not use these materials as replacements for their own notes. However, for those who can benefit from more active participation and less note taking, these strategies seem particularly helpful.

One reason students may have found negative results is due to the form of class notes I use, which are quite informal — little more than partially-outlined notes to myself on the topics I plan to teach, the ideas I hope to cover, and the general structure of the examples I expect to use. Often, what I end up teaching bears little resemblance to the set of notes I hand out. There are some compelling reasons for using less formal notes: informal notes can highlight key ideas and provide a glimpse into another perspective for understanding the material. They can also give students structure for discussion without excessively biasing the discussion. However, some

students who used these notes in place of their own discovered that their informality made them deficient. One student in the advanced class reported

> *Since most of what we did in class was on the outlines, I tended not to take notes, so I'd miss it whenever we talk about something not on the outline.*

There are other forms of notes and blackboards. Some instructors choose to use tightly-edited sets of notes that may be of equivalent quality to a chapter in a published textbook. Some use the web as a slide authoring tool, so that the printed outline can precisely match the projected slides or blackboards.

In addition to the aforementioned reasons, I find that many students prefer (or claim to prefer) informal notes and „on the fly" blackboards. In informal discussions of possible presentation techniques, many object strenuously to any form of prepared slide. Some object because they feel that slides prohibit a free flow of ideas in lecture; in their experience, instructors who use slides are not willing to look at materials from a different perspective, or to try an untested experiment in front of the class. Others object because they feel that slides encourage „lazy teaching"; in their experience, instructors who use slides have generally not bothered to rethink the material since they first created the slides. While neither perception may be correct, such negative perceptions can adversely influence student reactions to the course, and therefore decrease student learning. I also find that avoiding slides can better involve students: if students know that they can participate in the discussions, influence the direction of the course or lecture, and have their suggestions taken seriously, they will be more willing to speak up.

5 Summary

For these courses, the use of WWW-based resources has been successful. The students, like most college students, are still discovering how they learn. As such, it is still important for instructors to design the web in such a way that students are guided to more essential materials, while still having access to additional materials. Similarly, students should be reminded that there are different learning strategies, and not all strategies work for all students. With proper guidance to students and thought given to the overall design of the course web, WWW-based resources can be a successful addition to any course.

At the same time, instructors need to do more than just build webs. They need to evaluate the effects of these webs, both formally and informally. As the discussion above suggests, it is useful to ask students not only whether or not they used resources, but how they *perceive* the effect of those resources. Through good design and regular evaluation, positive educational effects can be ensured.

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