WWW TO SUPPORT CLASSROOM TEACHING

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Abstract: This paper evaluates the usage and perceived usefulness of the World Wide Web (WWW) to support classroom delivery of University courses. The study used qualitative and quantitative tools focusing on two undergraduate classes. Roger's (1995) theoretical model for adoption of innovation was used to identify and classify barriers to adoption of this educational innovation. An author developed survey instrument was administered to student participants and two focus group style class interviews were used to triangulate data from the survey instruments. Descriptive details outlining the process of developing WWW documents and navigational aids are provided.
The study revealed that the WWW is perceived by students and instructors as a valued education enhancement. There were, however, significant barrier to adoption including access restrictions, questions related to relative advantage of the technology, and problems in the creation and organization of large quantities of WWW pages.

Résumé: Cette article évalue l'usage et l'utilité perçue du Web comme élément de support dans l'enseignement universitaire. Cette étude, visant deux classes universitaires de niveau premier cycle, utilise des outils appartenant aux méthodes de recherche quantitative et qualitative. Le modèle théorique de Roger (1995) sur l'adoption et l'innovation a ete utilisé afin d'indentifier et de classifier les contraintes reliées à l'adoption de cette innovation en éducation. Un instrument de sondage a été administré aux étudiants participants. Deux entrevues de groupe des classes ont été utilisé afin de trianguler les données provenant des sondages. Des détails de nature descriptive illustrant le processus de développement de documents sur le Web ainsi que des outils d'aide d'utilisation du Web sont suggérés.
Cette étude révèle que le Web est perçu comme élément d'amélioration en éducation et cela par les étudiants et les éducateurs. Toutefois, des contraints d'adoption ont été soulevées quant aux restrictions d'accès, les avantages de la technologie et les difficultés de création et d'organisation d'un grand nombre de pages du Web.

Perceived Effectiveness of the World Wide Web to Supplement University Level Classroom Instruction

The World Wide Web (WWW) (December & Randall, 1994) has emerged as a user friendly system for accessing information and communication resources on the Internet. This ease of use, coupled with exponential growth in the number and quality of resources to be accessed, has resulted in the large popular and professional interest in developing applications using this medium. Educators are experimenting with ways to apply the concepts and tools of the WWW to learning and teaching applications (Saltzberg & Polson, 1995). This article reviews the process of creating WWW pages for support

of classroom delivery in two undergraduate courses at the University of Alberta. The paper also presents students' and teachers' data relating to perceptions of the effectiveness, utility and data on usage. It documents both the benefits and the problems that accompany WWW use and notes the need for critical evaluation, rather than impulsive adoption of the technology.

Theoretical Base

This study is based upon the model of adoption of innovation described by Rogers (1995). Rogers' model has been used for over 30 years in many contexts and has been found useful to understand the process of adoption of both technological and non-technical innovations. Rogers (1995) postulates that during the persuasion stage of adoption, when potential users are making initial adoption decisions, five characteristics of the innovation influence the rate of adoption. These characteristics are relative advantage, compatibility, complexity, trialability and observability. The results of this study address each of these issues and it is hoped that the somewhat detailed documentation of the process of creation and administration of this innovation will serve to enhance the "observability" of the innovation.

Research Questions

The theoretical model gives rise to two research questions bearing on the process of adoption and use of new technology:

1. Is the WWW perceived by students and instructors as a valuable aid to the teaching/learning   process?

2. What are the barriers (as perceived by both teachers and students) to adoption and use of this technology?

Literature Review

The world wide web (WWW) is a hypertext system which has been enhanced by the capacity to link not only text, but graphics, audio, video files and executable programs that are located anywhere on the Internet. To be effective, such a hypermedia system must be more than a linking of multimedia resources but must, in Jonassen's words, be a "network of nodes that are conceptually organized and interrelated by a linked structure", (Jonassen 1991, p.84). Determining an optimal design of this linked structure is a challenge to educators (Park, 199 1). Jonassen (1988) noted that one of the advantages of hypertext is the capacity to "represent in its own structure and presentation the structure of knowledge that it is attempting to convey". However, designing hypertext structures that mirror both the supposed structure of the knowledge domain and provide useful navigational learning paths through this domain is not an easy task. Further, some authors have claimed (Jonassen, 1988, MacAleese, 1990) that hypertext structures are ideal learning environments in that the complex linking structures, which can be created within

the learning materials, match the internal processing which takes place in the learner's brain. However, even if this assertion is true, it does not necessarily imply that learning is improved through use of structures which may model human brain activity (Morariu, 1988). WWW designers are thus presented with at least two different models for organizing their materials, one which looks to the subject matter to logically define the structure and a second which attempts to create a cognitive web which mirrors the students mental conceptions. In the cases described in this study, the designers have taken the former route and relied upon a highly structured overview of materials, designed to mirror the process of software engineering and the hierarchical classification of entomology.

Unlike more structured computer based learning modules, the hypermedia structure of the WWW maximizes learner control in that learners are free to follow or create multiple paths through the subject domain. Too much learner control, especially in large and complex hypertext documents, often results in students becoming disorientated or lost in the material (Park, 1991) with resulting frustration and lack of adoption. The designers in this study made special efforts to design navigational systems into the hypermedia so that students would have consistent guidelines and retraceable paths to guide their navigation through the subject domain. The success of their efforts, in reducing cognitive disorientation, should be reflected in the students' perception of relative advantage and thus, adoption.

Study Design

The study was exploratory in nature and used a mixed methodology employing qualitative and quantitative data to answer the research questions. The qualitative analysis was based upon case study analysis of the creation of the W WW coursewares, interviews with instructors using the WWW, a focus group interview with students enrolled in WWW supported classes, and responses to open ended survey questions. Quantitative analysis consisted of an author-developed questionnaire (http://nvquist.ee.ualberta.ca/~wjoerg/SE/forms/Ext_Ql.html) which was administered to students in a third-year software engineering course and to students in a second-year Entomology course.

Quantitative analysis of the survey was complicated by the different use of the WWW in the two classes. As Clarke (1983, 1994) has conclusively argued, the use of instructional design of an educational technology has a larger impact on learning than the technology itself The two sample classes used the technology in quite different ways, thus, combining the data tended to obscure rather than inform the research questions. Analysis of the classes in isolation reduced the sample size below levels upon which valid inferences could be made, and thus, data analysis was largely descriptive and must be considered as very exploratory. This paper focuses primarily on data from the software engineering students, and makes reference to the Entomology class only in comparison. The authors acknowledge that the different context of learning precludes direct comparison between the two case studies. We have however, included presentation of data in side by side format to illustrate perceived differences by student participants – we caution the reader to keep in mind that comparing apples and oranges helps us

understand fruit salad more than the qualities and characteristics of either fruit in isolation!

The   Teaching/Learning   Context

Objectives for using the WWW. The objectives for enhancing the classes with WWW tools were to:

1. build a set of highly structured and linked documents, with clean graphics and colour, suitable for class presentation;
2. make this set, plus additional in-depth material, accessible to the students for exploration and review "anytime", "anywhere";
3. provide an omnipresent opportunity for interaction between students, teaching assistants, and the instructor;
4. develop a mechanism to keep students, continuously informed about deadlines, project news, report formats, and problem sets;
5. simplify and automate the collection and evaluation of weekly logs and other submissions.

Summary of the main WWW concepts. The World Wide Web is a non-hierarchical, global system for accessing digital information. Although WWW display programs, called browsers, can display information designed for many Internet applications, the native language of the WWW is Hypertext Markup Language (HTML). HTML documents are in plain text format and can, therefore, be created using any text editor. Such text consists of the original text information annotated (or marked up) with "tags" to allow for formatting of the text, inclusion of graphics, sound or animation clips, highlighting of text or pictures for reference to other information, and setting up of input fields for interaction.

HTML supports a few simple but powerful concepts applied in a consistent manner. The most significant concept – linking- is a unified addressing scheme to access other documents (text, segments, graphics, sound or video) locally or externally at any site on the Internet with a simple mouse click. A link (or HREF) may originate from various entities such as arbitrary sized text strings, pictures or selected areas in pictures. Such origins are displayed visibly by net navigators by underlining, colouring or framing the active area (hot spot). The destination of a link is described by its URL (Universal Resource Locator) consisting of the transmission scheme, the site address, and the directory   path.

Links are followed by simply "clicking" on the active area of a link origin which causes the target document to be retrieved and displayed. Most browsers offer two buttons to provide sequential access of previously visited documents. The explored links can be traced backward, using the "back" button, and forward navigation, along earlier "backed" paths, is achieved through the "forward" button. Such sequential access can become tedious, therefore, browsers keep track of visited documents in a history menu, from which documents, visited earlier in the same session, can be selected randomly. The links to documents of particular interest can be saved from session to session as bookmarks.

Another important concept – forms – provides for user interaction through fill-in forms, which can be created at will with text input, check boxes, radio buttons, and hidden text. We have extended the basic e-mail feature on our server with a service that recognizes the various forms created for these courses, authenticates submitted forms, transforms them into an annotated e-mail message, and dispatches it to one or more destinations depending on the submitter's request. The authentication mechanism allows for form-dependent password specification and monitors the number of form submissions against limits specified for each individual password. Specific forms like the weekly logs are collected and routed to a program that transforms the message into a format readable by most spreadsheet programs.

<u>Navigating structured documents.</u>   Linking in HTML is unstructured and not constrained. The resulting freedom forces teachers to spend particular efforts into structuring educational material. In order to preserve the didactic value of those structures, and to allow for their systematic exploration by the students, particular care must be given to the use of links. We have followed a strict set of rules governing the use of links during document creation. Direct use of links is limited to backward referencing (to previous material in text, in problem sets, in directives, and to bibliographic references). Forward links are limited to the immediate sub-topics of a given page (topic), and to this effect all topics follow a generic (possibly recursive) structure consisting of a brief introduction and a list of sub-topics.

To facilitate navigation in structured documents we have incorporated two additional means for navigation. For relative navigation along the structure implied by the topic/ sub-topic hierarchy, each topic is preceded by a collection of four buttons: arrow left up (up to next higher level in the hierarchy), arrow left (to previous topic at same level), arrow right (to next topic at same level), and arrow right down (down to first sub-topic). For absolute navigation, important topics are headed by a set of named buttons that lead directly to frequently accessed pages such as home page, index, schedule, etc. It must be realized that these additional navigation tools are part of the document, and are subject to scrolling just like any other information displayed on the screen, Particular attention has been given, therefore, to the size of "pages" and to the positioning of the navigation buttons, such that repetitive use ("clicking") of the same button can be achieved without the need to move the mouse.

Figures 1 and 2 illustrate some of the above points. Fig. 1 shows the top lines of the HTML code that generates the "Feedback" page presented in Fig.2 (through Netscape). Lines 1,3,5 and 7 are part of the basic structure of an HTML document; the tags <html> and <body> are complemented with their respective "closing bracket" </html> and </body> at the bottom of the document (not shown); line 10 defines an anchor; lines 1 1 - 14 contain the references to the images for the relative navigation buttons, embedded into link descriptions that connect to other HTML documents (lines 1 1 - 13) or a local anchor #news (not visible) in line 14; lines 16 - 2 1 create a list of absolute (non-graphic) navigation buttons with their links; lines 25 and 26-28 create the course logo and the document heading respectively; lines 33 - 38 generate a group of six graphic buttons linked to local anchors, and lines 40 - 4 1 link a group of two buttons to other HTML documents (forms, in this particular case); lines 49 - 50   unordered list of subtopics itemized by "bullets".

Figure 1: Sample HTML code from the "Feedback" page.

```
01  <html>

03  <head>
04      <title>CMPE 313 - Feedback [SE_Fbck]</title>
05  <head>

07  <body>
08  <!-- Top Menu bar ++++++++++++++++++++++++++++++++++++++++++++++++++>
09  <HR size=1 width=100% noshade>
10  <a name=top> </a>
11  <a href=index.html> <img src=imgLib/navig/leftup.GIF align=absmiddle> </a>
12  <a href=SE_Schd.html> <img src=imgLib/navig/left.GIF align=absmiddle> </a>
13  <a href=SE_SEC.html> <img src=imgLib/navig/right.GIF align=absmiddle> </a>
14  <a href=#news> <img src=imgLib/navig/rightdown.GIF align=absmiddle> </a>
15  <font size=5>
16      [<font size=2><a href=index.html>Home</a></font>]
17      [<font size=2><a href=SE_Notes.html>Index</a></font>]
18      [<font size=2><a href=SE_Sched.html>Schedule</a></font>]
19      [<font size=2><blink>Feedback</blink></font>]
20      [<font size=2><a href=SE_FAQ.html>FAQ</a></font>]
21      [<font size=2><a href=forms/SE_Q.html>Q-form</a></font>]
22  </font>
23  <HR size=6 width=100%>
24  <!-- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++>
25  <img align=left src=imgLib/CE313_logo2.GIF hspace=5 vspace=5>
26  <center>
27      <H1>Feedback area</H1>
28  </center>
29  <BR clear=all>
30  <HR size=6 width=100%>
31  <P>
32  <center>
33      <a href=#news> <img src=imgLib/buttons/news.GIF> </a>
34      <a href=#deadlines> <img src=imgLib/buttons/deadlines.GIF> </a>
35      <a href=#tests> <img src=imgLib/buttons/tests.GIF> </a><BR>
36      <a href=#problems> <img src=imgLib/buttons/psets.GIF> </a>
37      <a href=#miscell> <img src=imgLib/buttons/misc.GIF> </a>
38      <a href=#overdue> <img src=imgLib/buttons/past.GIF> </a>
39      <P>
40      <a href=forms/SE_Q.html> <img src=imgLib/buttons/submit.GIF> </a>
41      <a href=SE_FAQ.html> <img src=imgLib/buttons/check.GIF> </a>
42  </center>
43  <P>
44  <center>
45      Last update: Sun, Apr. 23, 1995 13:00<BR>
46      <font size=+1><blink>Check this page frequently! </blink></font>
47  </center>
48  <P>
49  <UL type=circle>
50      <LI><H3><a href=#what>What</a> is the Feedback area all about?</H3>
```
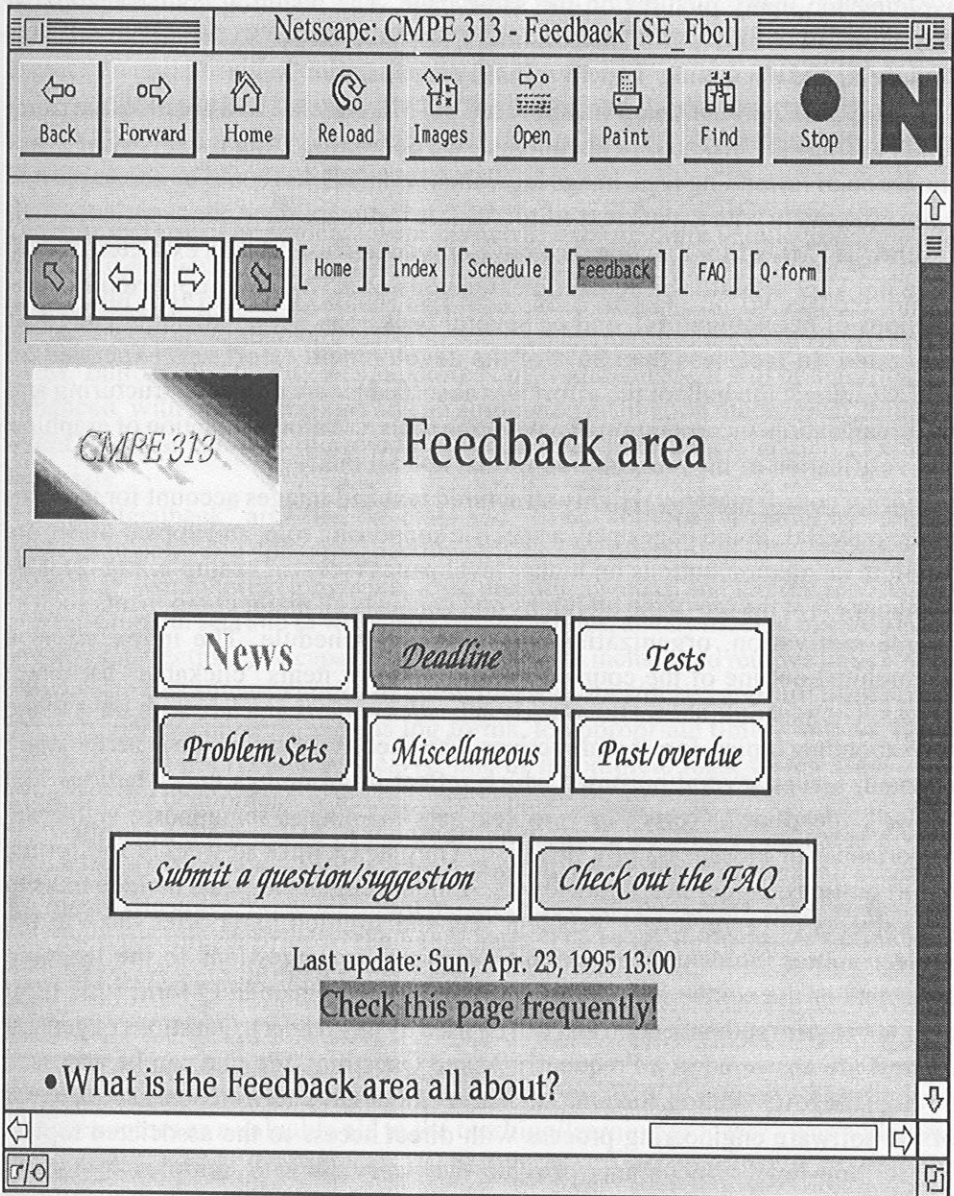
Fig. 2: Presentation of the "Feedback" page (code from Fig. 1) using Netscape

Process of creation of WWW learning documents. Starting from an initial set of over 400 transparencies, of which about 75% were available in computer readable form (text and black and white graphics), the entire software engineering course material was restructured for conformance with the above generic structure. In order to achieve an acceptable wait to load [reload] ratio for users accessing the notes through modem, the size of individual HTML documents was limited to a

range of 5 - 30 kilobytes. Particular attention was given to appropriate (i.e. sparing) use of graphics, limiting pictures/diagrams to the essence of their message, and avoiding too many pictures on the same page. The resulting course materials, after an effort of nearly 1500 person-hours, is a hierarchy of 850 files, nested up to six levels, and occupying 4.5 MB of hard disk space.

Through experimentation with several "HTML editors", and practice in writing (and reading) HTML source documents, we determined that most routine work (insertion of formatting tags, image tags, anchors and links) could be accomplished quite effectively with a plain text editor. This is fortunate since our experience with several "HTML editors" is that they have proven less useful than expected as they have not kept up with the syntactic extensions of HTML (as supported by new versions of net navigators), and on several occasions wrong attribute code was generated. In fact, less than 25% of the development effort was expended on "HTMLizing";   the bulk of the effort was absorbed by document restructuring and file organization, incorporation of navigation tools, creation/adaptation of graphics, and verification of the presentation format and all links.

Resulting course material. Highly structured text and images account for the bulk of the material. Some pages play a specific supporting role, and appear under the absolute navigation buttons on higher level pages (see, for example, Fig. 2). The homepage is at the top of the hierarchy and connects all major components such as course motivation, organization, material and schedule. The index offers a hierarchical outline of the course topics, with most items "clickable" for direct access. The schedule shows the weekly activities in class and lab, with links to the corresponding topics, forms or directives. The Feedback area which is periodically updated, serves several purposes which reflect in groupings under buttons like "news", "deadline", "tests", or "problem sets". Coloured semaphores signal the importance (or closeness) of a deadline. They boast links to weekly log forms, report outlines, guidelines, or standards. Announcements for tests include links to the subjects to be reviewed. Problem sets and solution hints offer links to the subject matter. Students may submit questions or suggestions to the teaching assistants or the course instructor by filling in a form named Q-form (this form does not require authentication and can be used by any reader). Questions of general interest are answered in a Frequently Asked Questions-file that can be accessed through the FAQ - button. Several "clickable" maps have been created as overviews of the software engineering process with direct access to the associated topics. These "top-level" documents provide the overview to a complex hypertext environment necessary to provide cognitive boundaries to a virtual text (Kearsley, 1988, p. 21).

Access to the electronic course material is possible from any platform connected to Internet and capable of running a WWW net navigator. Off-campus access was made possible through a large 250 installation modem pool and SLIP7/PPP accounts on the University network.

Method of Use

<u>In-class use.</u> The classes were scheduled in a newly renovated, multimedia classroom. The room supported access to the university network, and a large screen projection unit provided output display for the class. The top layers of the course material were projected through these facilities, and used to support the lecture and in-class discussion processes (structure of topics, key points, illustrative examples and reference to earlier material).

<u>Out-of-class use.</u> The students were invited to explore more detailed information in the lower levels of the hypertext on their own. By using the course schedule, they could find upcoming topics and read ahead of lectures. In selected topics, students were presented with self-assessment questions by "clicking" on an active "Test" button. This facility was supported only rudimentary; it will be significantly enhanced, with more questions and an automated evaluation mechanism, with the intent to assist students in providing feedback on their understanding of course materials.

The "feedback" area tied the class and project activities together by alerting students to news and upcoming deadlines. This was accomplished by changing the colours of semaphores (for weekly logs, meeting agendas, and interim reports), by posting problem sets and (a week later) solution hints, and by moving overdue items to a separate section. The capacity for the teacher to include and remove links at will, allowed for fair advance notice of upcoming activities/duties and still limit access to particular documents, such as log forms, to appropriate time windows. (As a result, we did not receive any early, late or incomplete logs, which are a quite exasperating phenomena when logs are in paper form).

Following the practice of the traditional course setting, examinations were "open book". They were held in a computer lab, providing students with access to the electronic notes. Students could install their own "bookmark files" of familiar netbased resources, prior to the exam start. The exam description and answer booklets were in traditional paper form.

Results

<u>Student perspective.</u> The research question "Is the WWW perceived by students and instructors as a valuable aid to the teaching/learning process?" was addressed by separate survey items which queried student perceptions of at the various components of the WWW system. Students were asked to indicate the amount they used the various components of the WWW support system (Likert scale l-5 where 1 is never used and 5 is used frequently). They were also asked to report the perceived usefulness of each component (Likert scale   where 1 is not useful at all and 5 is very useful). The results are reported in Table 1.

Table 1: Amount of Use and Perceived Usefulness of Components of WWW Support
Likert scale l-5 where 1 is never used and 5 is used frequently.

	Software Eng. n=24 Amount Used Mean	Usefulness Mean	Entomology n=36 Amount Used Mean	Usefulness Mean
Class lecture notes and summaries	4.00	4.17	3.49	3.97
External WWW links	4.08	4.46	1.50	3.27
Course schedule & syllabus	3.75	4.08	2.11	3.97
Problem sets and test answers	2.92	3.76	2.31	3.53
Administrative Announcements	3.63	3.80	1.46	3.00
Private e-mail to other students	2.08	3.02	2.00	3.26
Private e-mail to professor	2.22	3.17	1.33	4.00

The three items related to use of course materials by the software engineering
students (syllabus; lecture notes and summaries; problem sets and test answers)
indicate a high degree of usage and perceived usefulness. The use of the system to
browse other materials on the WWW including resources on the University campus
and external resources also had high levels of reported use and perceived usefulness.

A second component of acceptance is actual usage. Software engineering
students reported a mean of 6.9 logins per week (range of 2 to 15 and SD of 3.62)
with a mean of 8.63 hours ofon-line time on the system. Both these means indicate
significant usage of the system by undergraduate students.

The WWW was used in the Entomology class to provide access to the course
syllabus, some class notes, and as a source ofgraphic images. The Entomology course
used the system only for certain portions of the class and therefore it was used in a more
periphery manner than the software engineering course. This less integrated use of the
WWW system, resulted in a much lower usage (mean of 1.5 logins/week, range 0 to 8,
SD of 1.42 with a mean of 1.8 hours per week on-line). The amount of use and perceived
usefulness of the WWW system was also significantly lower amongst the Entomology
students (see Table 1).

Perceived value in an educational context must be grounded in comparison to
other learning resources. Thus, students were asked to value the WWW pages in
comparison to other resources and the results are shown in Table 2.

Table 2: Perceived Value of Learning Resources where l is Useless and 5 is Very Valuable

Learning Resource	Software	SD	Entomology	SD
Lectures	4.04	86	4.35	.90
Labs	3.92	.93	2.60	I.55
WWW Pages	3.58	1.14	3.14	I.45
Assignments	3.58	I.06	2.94	1.29
Examinations	3.13	1.08	3.50	1.32
Texts	2.96	I.13	2.88	I.49

It is interesting to note that the lectures are perceived as the most valuable learning component of these courses. This implies that the WWW pages were not used in a stand-alone manner such that they could replace the lectures for time or place bound students. It is also interesting to note that the WWW pages were perceived by both classes as the third most valuable resource with ratings higher than the text book in both classes.

A final indicator of perceived value was the question related to preference for future use. Seventy-one percent of the software engineering students and 94% of the entomology students indicated that they would like more of their courses to use WWW support. It is somewhat surprising to find the entomology students more interested than the engineering students in expanded use of this tool, given their lower perceptions of value. Perhaps this illustrates the somewhat naive first impression of the WWW experienced by many new users – that this tool is tremendously powerful and entertaining – a sentiment that can wane after more prolonged exposure as experienced by the engineering students. In summary, the perceived usefulness data indicates that the students perceived the WWW enhancement as a valuable component of the learning experience in both classes and that students looked forward to more WWW support in subsequent courses.

<u>Barriers to Use.</u>The survey asked ten questions related to potential barriers to use and adoption. The results of these items are shown in table 3.

Table 3: Perceived Barriers to Use

Student Perceived Barriers to Effective Use	**Software Eng.** mean score 1 =no barrier, 5=major barrier	SD n=24	**Entomology** mean score 1 =no barrier, 5=major barrier	SD n=36
Inconvenient access to terminals	2.33	0.46	2.50	1.13
Inadequate training	1.29	0.55	3.34	1.62
Difficulty logging in to system	2.17	1.37	2.95	1.35
Poor keyboarding skills	1.29	0.81	1.57	1.20
Difficulty reading screens	2.17	1.17	1.59	1.06
Saw no value in using the system	1.46	0.72	1.49	0.93
Kept getting lost in the pages	2.83	1.20	1.79	1.24
Slow speed of the system	3.08	1.25	2.09	1.14
Inability to connect from home	3.75	1.48	2.99	1.71
Difficulty in learning to use	1.29	0.46	3.19	1.53

The Software Engineering student sample were all competent computer users with 100% describing themselves as being at either intermediate or expert levels of computer expertise. Thus, barriers of poor keyboarding skills (mean of 1.29, where 1 is "no barrier at all"), inadequate training (mean of 1.29), difficulty in learning to use the system (mean of 1.29) were not reported as barriers to usage.

Higher barriers amongst the Engineering students related to access with 67% of the students (mean of 3.75 where 5 is a "major barrier") reporting that busy lines resulting from crowded modem pools were a barrier to their use of the system. Students also cited the slow speed of the system as creating a barrier (mean of 3.08). Consistent with the literature on hypertext (Neilson, 1990) is the problem of students getting lost in multi-paged systems. Early reports of this barrier caused one of the authors to completely reorganize the WWW pages and add additional navigational links to existing hypertext course notes.

As expected, the less computer experienced Entomology students (3 1% self-described as novice users) reported higher barriers to usage. Factors of inadequate training (mean of 3.34 where 1 is "no barrier at all") and difficulty in learning the system (mean of 3.19) were reported as barriers to usage. Like the software engineering students, Entomology students also reported problems accessing the system both from labs and from home.

Qualitative results. During the focus group interview, a number of interesting factors emerged which were not captured in the survey data. Generally the students were supportive of the professors' efforts in experimenting with the technology. They were, however, not without complaint nor did they report uncritical acceptance. Issues of access were at the heart of many student comments. On the one hand, access to course materials is improved as they are accessible 24 hours a day from any machine connected to the Internet. As one Entomology student commented: "If you miss something in class – you can look it up." On the other hand, access is restricted to locations where networked machines are located – thus, precluding study and review on buses, in non-networked classrooms or when access to the modem pool is restricted. Despite the University of Alberta having doubled its modem pool in the past year to over 250 modems, increases in demand result in very long delays for   access during the day and early evening hours. Until students have access to Internet resources through alternative suppliers, the University will be met with an almost insurmountable barrier of providing ever increasing numbers of modems. The University is attempting to resolve this barrier by negotiating special access through commercial Internet suppliers which will charge a time-based, usage fee for this service. To facilitate access, students suggested that the electronic notes be made accessible off-line (e.g. by downloading as compressed archives, or through external media such as diskettes or CD ROM). This was done in the second offering of the Engineering course, providing the WWW pages in compressed "zip" format which students could download and expand on their own machines, so that students could access the non-interactive components of the course without being connected to the Internet.

A negative pedagogical impact of WWW use was reported by a student who noted the incapacity to annotate, highlight, and add personal notation to class materials. This capacity is widely used by students reviewing and studying from textbooks and other printed materials. The capacity to create connections, enhance with personal anecdotes, and otherwise "personalize" and make new material personally relevant, is a crucial component of deep learning (Ramsden, 1992).

Future applications of the WWW for educational use will need to develop tools whereby students can easily highlight, cut and paste, and otherwise personalize class notes.

A number of students reported appreciating the hypertext linkages embedded in the course material and the resulting capacity to review the content for areas of personal interest. One software engineering student commented: "I can follow the flow of the information that you require without having to read through a bunch of stuff that is not relevant to what you are looking for." There were also a number of comments relating to the inappropriateness of current computer monitors for reading large amounts of text-based materials. One software engineering student commented: "I get (physically and mentally) tired after looking at a computer monitor for long periods of time. I find using paper notes not as hard on the eyes as using a computer for reading. The computer is a great tool, but I don't think it is where large amounts of reading can or should be done."

Finally, some students reported concerns over the time spent exploring external WWW sites. This perception of the WWW system as "time wasting" probably reflects the capacity of the WWW to divert users into interesting and entertaining, (but potentially unproductive) "surfing" of WWW sites.

To summarize, students reported that the use of WWW changed the dynamics of access by facilitating the use of class materials at any time and from home or class laboratory. Students also reported enhancements to the speed with which class materials were revised by the instructor, enhancements in their capacity to review materials, and reduction in the amount of paper consumption in the course. Most negative comments related to access problems that were due primarily to restrictions in hardware and telephone line availability and to the inability to personally annotate class notes and materials.

<u>Instructor's perspective.</u> Not all of the features built into the WWW system were used by students. For example, only a relatively few students made use of all the electronic reading material made accessible on the system. The feedback section, however, was often visited and it was important to evaluation conscious students that the deadlines and news sections were updated frequently (with inclusion of time and date of the last update). Relatively little use was made of forms for submission of questions to the instructors (on average one question per day from a class of 35). The use of electronic forms for submission of assignments and reports was widely used and resulted in quicker evaluation returns and better capacity to track class progress.

Adding relative navigation tools simplified the mechanics for classroom presentation. Their impact on the notes as a learning tool, however, is ambivalent. On one hand, very positive feedback acknowledged the ease of navigation; on the other hand, the majority of students insisted on obtaining hard copies of the notes, and in general they preferred copies of the old, more "sequential" notes, to printouts of the highly structured electronic notes. The preference of sequential text over highly structured material seems to be related to different phases of learning: during the first exposure to new material, students wanted to make sure they covered it

all, which favours sequential organization; whereas a highly structured organization was preferred for reviewing "known" material. As a consequence, it appears that (at least) two documents with different styles ought to be generated from the same source material. We are presently looking for effective ways to address this dichotomy.

Developer's perspective. Developing a WWW based course is time consuming. In spite of having much of the course material available in electronic form, a total of 1400 - 1500 person-hours were expended to create the full set of WWW notes. Keeping proper track of all links in a maze of more than 800 tiles was a challenge. Proper file organization, consistent with the topic hierarchies simplified the problem, but we are still in search of development tools that offer real support in managing such complexities. Most documents followed a generic structure which allowed the creation of templates for the few different types of documents required. To make the documents more readable (and therefore more maintainable) we successively refined (and followed) rules for HTML style dealing with item separation, heading sizes, indentation, anchor naming, etc.

Discussion

This case study, of early use of WWW tools to support classroom mstruction, reveals that the tool has unrealized potential. Rogers' theoretical model suggests that the innovation must be perceived by the users as offering relative advantage over traditional ways of accomplishing the same task. Relative advantage of WWW delivered materials is less apparent for students who are on-campus on a daily basis and for whom access to learning materials is generally taken for granted. We speculate that relative advantage would be much higher for distance education students for whom access to learning materials would otherwise consist of a long physical journey or even be impossible by any method except those that support distance access. A second area of relative advantage, for traditional teaching above that in a WWW enhanced environment, is the difficulty for students to annotate and personalize materials. New tools are needed which allow students to store, update and share annotations to materials presented in HTML format. Developments in WWW capacity such as client based programming in support of computer assisted learning will add relative advantage to the WWW in coming years. The greatest relative advantage is yet relatively unrealized, but indicated by the high usefulness score reported by computer engineering students relating to use of external links. Since this data was gathered in April 1995, the volume and quantity of network resources relative to software engineering and most other disciplines has grown immensely. We see huge relative advantage in linking learning, documentation and even promotional literature on the nets to traditional course syllabi, this creating a vibrant and growing resource base which students can continue to interact with long after the conclusion of the formal course. The relative advantage gained by more exploratory forms of learning supported by access to diverse and plentiful WWW resources promises new ways of approaching learning (Pea, 1993). These developments hold promise for the creation of learning

environments capable of sustaining interest and use by lifelong learners long after the course has been completed.

Rogers' second characteristic, compatibility, is illustrated in the different degree of usage between the two student groups in this study. The software engineering students used computer tools on a regular and frequent basis and, thus, addition of WWW documents is compatible with much of the work that they perform. For many of the Entomology students, accessing the WWW documents entailed learning to use new computer tools and application software, some of which is incompatible with current practices -thus, adoption and use by the Entomology students was much lower.

Complexity, as a factor in adoption by students, is dependent upon the tools used to access the WWW pages. Users with the "point and click" and consistent user interface of graphical browsers (such as Netscape Navigator) were able to access the pages with relative ease. Those unfamiliar with computers and those using text based browsers found the medium more complex and thus, had lower rates of adoption. Complexity for course developers and teachers is a major barrier to adoption. We are concerned that the development tools necessary for teachers to easily author and coherently organize large quantities of course materials are not yet available in WWW. Early adopters, are forced to use first generation creation and maintenance tools and navigation techniques which are desperately in need of improvement. The recent introduction of "frames" by Netscape provides a capacity to maintain navigational aids on the screen despite changes in accompanying content frames. The latest version of the computer engineering course makes extensive use of this frame feature. We continue to develop courseware today, waiting for, developing and incorporating better tools as they become available.

Perhaps the greatest value of WWW as an innovative application of network-based learning is the ease with which single pages can be created and trialed in face-to-face or distance application. Initial developments can be as simple as marking up the course syllabus or creating links to other subject related content on the WWW. Thus, the medium is trialable and can easily be used as a publishing and distribution system for course materials.

The final factor in Rogers' adoption model – observability – is also not a constraining factor in the adoption of WWW technology. Documents placed on the World Wide Web can easily be observed by other students and instructors on-campus as well as by anyone with access to the WWW. This observability is key to the rapid development of WWW documents as new users view and incorporate the design ideas from other sites into their own works.

Rogers' theoretical model helps explain the variation in adoption between the two classes in this study. The relative advantage for on-campus students seems to be the largest factor inhibiting adoption. We speculate that WWW will be most readily adopted by students for whom access to educational resources via the networks is the only, or preferred option, to face-to-face instruction.

Recommendations for Further Research

This study focused on the perceptions of students and their willingness to adopt a new learning/teaching technology. We acknowledge that perception data is only the first in a sequence of information needed to evaluate educational innovations. Phillips (1996) notes four other areas   namely specific learning; transfer to other application domains, measurable results and return on investment. We must continue to expend time and energy evaluating these additional and often more difficult components of a holistic evaluation. Positive perceptions and adoption are important, but evaluating both the cost and leaning effectiveness of the innovation is an essential next step.

Conclusion

We believe that the WWW will be a major component of a re-engineered university system that seeks to provide quality education which can be delivered independently of time or distance. The WWW also has a place in more traditional face-to-face delivery of university courses. The capacity of the WWW to display class materials as presentation graphics in class; be used by students at home or in the labs; and be used as the front end for more elaborate computer assisted learning and computer conferencing systems; and to access other net resources, makes the WWW a valuable educational tool.

Note: Interested readers may explore the current versions of the two courses discussed in this article at the following addresses. Please note that extensive revisions have been made to both courses since the date of the evaluation reported here.

Software Engineering 3 13 at: http://www.ee.ualberta.ca/-wjoerg/SE/

Entomology 207 at: http://gause.biology.ualberta.ca/

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