OnLine, Web Based Learning Environment for an Information Systems course: Access logs, Linearity and Performance

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Abstract

This is a study of an online, Web based learning environment developed for an introductory business information systems course. The development of the environment was guided by a design principle that emphasizes choices regarding hypertextuality, centralization in client-server, interactivity, multimedia, and synchronicity. The environment included a several hundred page textbook and individual and group online learning aids and implements. Following the development period and a pilot class, the system was used by students in three large classes of 50 - 100 students each. We examined student grades, attitudes, and usage logs and their intercorrelations. Our findings indicate that online, Web-based learning environments are not just feasible. Employing such a system to complement lectures yields measurable enhancements. We propose a focus on logged, machine-collected usage statistics. Such statistics allow a measurement of actual reading behavior and linearity in the learning process. Reading amount is highly correlated with student achievement. A-synchronous conferencing tools enhance instructor-student and student-to-student interaction. This interaction is, itself, a correlate of success in the course. Furthermore, more mature student groups seem to make better use of the online environment, and use it less linearly.

Introduction and Literature

Technology in education has come a long way from traditional tools through print, radio film, TV, VCR, CAI, all the way to CD-ROM's, satellite mediation and the internet (Acker, 1995, Beller, 1997).However, many of the technologies raise criticism. For instance, Cameron (1994) and Cuban (1986) conclude that most technologies fail to adequately address the real needs of teachers in classrooms. "[They] become the media of choice not because they were deemed to be the best but because they were available at the time" (McMahan & Dawson, 1995). Is the internet's role in instruction any different? Will computer-mediated technologies deliver more than earlier technologies?

Learning online

Computer-mediated communication has several main characteristics. These include hypertextuality, interactivity, multimedia/multisense, absence of defined center (packet-switching), and elasticity of synchronicity (Newhagen and Rafaeli, 1996). Each of these dimensions represents a choice faced by the system designers. For example, hypertextual structure requires careful planning. "Hypertext system should include explicit representation of network structure in its user interface... At any given time the user sees only the current node and links leading out from that node ; it is up to the users imagination to picture how the entire network is structured" (Nielsen, 1990). The purpose of this paper is to examine the impacts of the choices made by designers on the effectiveness of online systems. We will begin with an overview of the issues with online learning systems as outlined in previous research. We will then turn to suggesting a focus on access logs as an evaluation tool, and introduce the notion of nonlinearity as an important dimension in web-based browsing.

With the WWW , knowledge has become dynamic and interlinked. Anyone including students can provide information. Anyone can access learning materials in any route, any place with Internet connection (Wheeler et al., 1995; Mak, 1996). Lemke (1985) suggested that since hypermedia are generally meant to be read with essentially the same environment as the one used in authoring, reading becomes a sort of virtual writing. Stonier phrases the importance of computers in education figuratively: "The use of computers in education is the most important single advance in pedagogy since the invention of grandmothers, Grandmothers are the oldest information retrieval system in the world " (Tapscott, 1996). Can the case be made for the internet being more like grandmothers than any of the preceeding technologies?

In this study, we focus on the characteristics of internet-based education environments, and their role in learning. The proliferation of computer based applications reflects at least two major influences. One is the explosive growth in importance of information technology in the workspace, and the second is a growing body of evidence that students learn and better retain what they learn when engaged in authentic learning tasks (Glennan & Melmed, 1996).

Following Rouet & Levanon, (1996) and Dee-Lucas, (1996). We are interested in the efficiency that hypertextual and interactive presentation may bring to the learning experience, as well as in the tradeoff between the power of linking and search tools and the cognitive demand or costs these tools impose on the reader. The power per cost ratio can be improved in two major ways; first, by providing structural cues that make hypertext look like the traditional text structures readers usually rely on, and second, by improving the readers hypertext literacy, that is by helping readers become 'hyper-readers' or expert in the use of nonlinear text. However, students will need to learn strategies for navigating in large works perhaps with the aid of visual maps of the works content domains and types (Lemke, 1993)

What do evaluation studies say about computer based instruction? While the term "computer based instruction" is rather broad (Kulik, 1994) some common supportive dimensions have emerged (Norman, 1994a & b). Riel (1990) and Bump (Bump, 1990) found that "the most intense collaboration occurs when computers electronically linked to each other to form networks" this evidence was also support by Davits, 1988; Din, 1991; Levin & Cohen, 1985; Owen, 1991; Resnick, 1992; Riel, 1990; Riel, 1992; Robinson, 1993; Sloan & Koohang, 1991; Tinker, 1993 (Silva & Breuleux, 1994). "Another reason for the enthusiasm found for educational networking projects is the belief that students using computer networks are able to contextualize and cognitively situate learning tasks" (Silva & Breuleux, 1994). Carvin (1996) reports that "there is a solid backdrop of empirical analysis to support the positive nature of interactive learning".

It is still true that most of the reports on employing internet-based systems in education are anecdotal, single-case, small class oriented, and descriptive in nature. Nevertheless, the most recent research indicates that interactive, self directed learning and higher order thinking can be fostered by technology and that technology can have the greatest benefit when the environment is conducive to such experiences (Wellburn, 1996). "In courses which used the WWW to provide on-line copies of the paper administrative documents and a few supplemental materials there was almost no student use of the online resources even if they have easy access to computers. In

contrast, in courses where crucial materials, such as assignments are available only online the students are more likely to use both the required and optional materials" (Butler, 1995). "Themost important feature for characterizing distance education is not its morphology, but how communication between teacher and student is facilitated.. attention has been paid to the nature of communication process and the role of technologies in supporting it " (Shale & Garrison, 1990). "Other then one comment about availability of the lecture notes there is nothing in this feedback to indicate that having the materials on line provided extra benefit for the students" (Butler, 1995b) "Research and practice suggest that, appropriately implemented, computer - and network- based technology can contribute significantly to improved educational outcomes. Most of this experience is in small trials in one or a few settings, but has aggregated these experiences into a significant body of literature that illuminated the potential of technology in variety of settings" (Glennan & Melmed 1996). Almost half (47%) of Kenion's students (1997) thought that the greatest disadvantage owns the lack of lectures. The same rate wants to hold class, 12% need faster response from the course team. 68% will advice their friends to learn this course. Andres (Andres, 1995) list 9 positive points in "teaching in the virtual classroom" including the equal opportunity for input class discussions and customizing time to schedule. Tucker (1995) and Polyson (1996) find the most important advantage is that each student can follow his path of navigating and in his time "But online students will still need plenty of direct contact with live teachers for guidance, advice, and encouragement" (Crawford, 1994)

One of the most recent empirical studies was conducted by Schutte (1997). Thirty three sociology students were randomly divided into traditional classroom and a virtual classroom. Virtual classroom students scored an average 20% higher grade than the traditional class. Further, virtual classroom students spent significantly more time on class work. Hart (1996) found that, when compared to full time students, part time students were a) less likely to only seek information when they need it b) found navigating the hypertext links easier, c) more likely to prefer to use the web pages on their own d) less likely to prefer printed material over web pages. Specific applications of technology show improvement in student performance, student motivation, teacher satisfaction, and other important education outcomes (Glennan & Melmed 1996). A meta analysis of empirical studies of computers in education concluded that: "students usually learn more ... learn their lessons in less time ... like their class more .... develop more positive attitudes toward computers .... in class in which they receive computer based instruction [but] The average effect of computer based instruction in 34 studies of attitude toward subject matter was near zero.." (Kulik, 1994). Another meta analysis found that "technology appears to be equally effective for knowledge and performance outcomes" and "introduction of technology improves the effectiveness of instruction"(Fletcher, 1996). This evidence was also supported by SPA research which also conclude that "Education technology has been found to have positive effects on student attitudes toward learning" and "Online telecommunications between different geographic locations improved academic skills" (SPA, 1996).

The reports on online educational systems include some cautionary lessons. Gray (1987) concluded that students who are offered multiple choices in CAI lessons and required to make decisions may feel overwhelmed by the prospect of making decisions. "Gillingham, Garner, Guthrie and Sawyer found that students have trouble

identifying relevant information from irrelevant in computer assisted lessons . Butterfield and Nelson concluded that more successful learners were able to identify which elements or components in something to be learned were critical and which were not " (Cates, 1991). Not all use is online, even when that was intended. For instance, Butler found that "of the six students who returned the survey, five of them said that they regularly printed some or all of the materials." (Butler, 1995). Albrekson suggests that "... the orientation to e-mail ... was not nearly effective as online student to student counsel" (Albrekson, 1995). Nevertheless, Fletcher (1996) reports that "based solely on the amount of time students spent in computer based instruction they could predict to the nearest tenth of grade placement and within 99 percent confidence limits" (Fletcher, 1996). The design of the user interface "can have important consequences for the implementation of CMC in online education" (Ahern & Repman, 1994). Butler concludes that some of the main benefits of having administrative documents on line are increased availability of materials for the students and greater flexibility and decreased need for the instructor to maintain paper archives. The costs of having on-line administrative documents on-line are in time required to create the documents, to maintain the "news" portion of the materials, and to learn about WWW, HTML and associated tools (Butler, 1995). Butler further suggests to structure the course materials so that it is possible to reach every significant document in no more then 5 mouse clicks (Butler, 1995). Daonian (1996) taught chemistry via a listserv (an a-synchronous e-mail-based discussion group that supports the sharing and exchange of information) and found that "on-line chat and videoconferencing help increase participant interaction ... [however] Some students found it time consuming to type up everything in order to communicate with the class" (Daonian, 1996). Alavi (1994) and Wheeler et. al. (1995) found that group decision support systems enhanced student learning and lead to higher levels of perceived skill development.

In summary, online teaching is coming of age. The main issues related to the construction of online learning environments are tied to the main characteristics of such systems: interactivity, hypertextuality, centralizing vs. decentralizing (packet switching), multimedia and synchronicity. The success or failure, and the lessons regarding improving such systems are intricately woven into these characteristics. We propose to use these characteristics in the design and evaluation of an online learning environment for information systems. Furthermore, we propose to attach empirical measures for these characteristics, using an innovative analysis of the computer-recorded access logs.

Using access logs

Accesses to Web servers are recorded meticulously. Every request by a "client" results in a record of the date and time of the request, the transmission protocol and result status, amount of information sent, and the address of the client. If the file is protected in accordance with RFC-931, the actual username may be recorded as well. Web servers (http daemons) also keep record of errors, agents, and referrer address. See Musciano (1996) for a detailed description of record logs.

In a critique of the marketing use of access logs, Stehle (1995) argues that access logs are networking-centric, not marketing centric. While many rely on the raw size of the

usage log, or even the more primitive "counter", these methods are neither reliable nor valid measures of a site's quality, success or contribution. As the World-Wide-Web is "sessionless", such measures do not distinguish between "popularity" and multiple visits by one person. Nor do they identify the users or their behavior. Usage logs do not automatically distinguish between content and accompanying graphics. Dynamically generated content is not recorded. Offline reading of printed or downloaded material, mirroring, caching and proxies intervene and may bias the data. Finally, privacy and ethical considerations cf. Boehelfeld (1996), Duncan (1996) and Thomas, (1996) stand in the way of more widespread use of access logs.

Nevertheless, the enormous potential and rapidly growing business of advertising on Web sites have fueled an interest in marketing applications of usage logs and the information they contain (Cyberatlas, 1996). Mare refining the terminology and reliance on data available in these logs (Novak & Hoffman, 1996). For instance, marketing use goes beyond the raw data to employ a better distinction between hits, requests, visitors, users, identified users, and visits, and sessions. Hits are the number of page and/or graphic files requested by visitors. Requests are hits that successfully retrieve content. Visitors are individuals who visit a web site. Users are uniquely identifiable persons. An accurate count of users is made possible with additional registration or authentication. An identified user is a user for whom demographics are known and available. A visit is a sequence of requests made by one user, and a session is a series of transactions performed by a user that can tracked across successive Web sites.

Measurement tools, such as those evolving in the marketing arena may be adapted for the purposes of education, in the design and evaluation of online learning systems.

In summary, "[...] IT will empower students to have greater control over the learning process, with all the benefits associated with active learning and personal responsibility." (Massy & Zemsky, 1995). Governments have been advocating national information infrastructures arguing that computer based instruction is cost effective. Whether we like it or not, economic realities are of larger classes,. We should expect "30% more learning in 40% less time at 30% less cost. More effective, faster, and cheaper teaching are benefits that administrator of the creaky North American educational systems and beleaguered taxpayers cannot afford to ignore"(Tapscott, 1995). The demand for IT based teaching and learning programs will grow substantially, probably exponentially (Massy & Zemsky, 1995). However, "the introduction of any new technology into classrooms is difficult, especially in light of previous statements made about them in past" (Silva & Breuleux, 1994) Froese-Germain & Moll add that we do not know what the effect will be for the introduction of computers into schools but we almost certain that there will be a major effects which have not been anticipated (Froese-Germain & Moll, 1996). Empirical data collected via access logs may assist in a rational implementation, and will contribute to an orderly evaluation.

The Course

Our Business School required during the past two decades an introductory, semester long, Management Information Systems course as part of the required core

component of business education for both undergraduate and MBA students. The course covers a wide field of topics, ranging from definitions of information, its value and measurement, through organizational impacts, surveys of technological concepts of hardware, software, databases, data communication, artificial intelligence applications to business, legal and policy considerations, and design and analysis tools and practices.

As of 1996 this course was transformed into an online learning environment, placing materials on a Web server to support ongoing regular lectures. Several motivations guided the development of this system: (1) **Language**. English is a foreign language for most of our students. The only available textbooks in the field that are up-to-date are in English. Creating Web-based learning environments allows us to create a native language version for the fraction of the cost and time required in making textbooks. (2) **Fexibility**. The subject matter changes frequently, rapidly outdating most textbooks. A two year old textbook is not likely to mention the MMX processor, discuss the Java language, report accurately on legislative changes, or emphasize the centrality of client server technology. (3) **Availability**. Textbooks are very expensive. With new editions each year, a $70 textbook has little resale value, hence students were less likely to purchase their own. (4) **Portability.** A Web-based learning environment enables use at a distance, even when the traditional weekly meeting structure is preserved. (5) **Interaction.** Opportunities for interaction are actually (and paradoxically) enhanced in a-synchronous online environments. Not only can interaction take place around the clock and all week, and is no longer limited to class and office hours. Interaction is also less encumbered by the co-presence of dozens of other students. Online learning environments also make possible the highlighting of the cognitive interaction between various concepts in the subject matter, and student-to-student interaction, a hallmark of small groups that is largely unavailable in the standard, huge introductory core classes. (6) **Cost.** Publishing in an online environment is less expensive than the production of a regular textbook, while allowing many more illustrations, use of color and animation, etc. Furthermore, the environment shell can now be used for other courses. (7) **Research.** However, we were primarily interested in developing this environment for the exciting research potentials made available through it. Surely, lessons learned in an environment of this nature are applicable to other uses of online systems such as marketing, politics, and management.

The introductory course in information systems, using the online system, was offered four times during the last year. There was one "pilot" class of 80 students which used the system as it was built, and three classes which used a fully implemented system. The following data pertain to the these three classes: An undergraduate (BA) class, 120 students; a graduate (MBA) class, 80 students; and an "Executive MBA" class, 40 students. Table 1 displays the formats and class components for each of these classes.

TABLE 1: Classes and uses

	BA	MBA	EMBA
Textbook	WWW	WWW	
Exercises submitted via	WWW	WWW	
Lab lessons	1 hr/week		

Lecture	2 hr/week	3 hr/week	3 hr/week
Semester length (weeks)			
14	14	8	

System design and components

The online environment was a frame-based WWW system, allowing access to 340 static HTML pages, 280 illustrations, hundreds of dynamic pages, and a few dozen Java and Javascript applications. Illustration 1 presents the three frames used. The right-hand frame contains a dynamic, collapsible **table of contents** for the textbook portion of the system. (Hebrew is written right-to-left). The table of contents displayed, at first "load", the nine chapter headers. A click on a chapter header "unfolds" a list of links internal to that chapter. The bottom frame contains ten buttons pointing to various tools. The upper left hand frame is the central work area. Text pages, illustrations, and applications are displayed in this area . The system contained 1126 links. Of these, 233 links are available on the screen (the bottom ten pointers to tools, and 233 chapter headings in the table of contents).

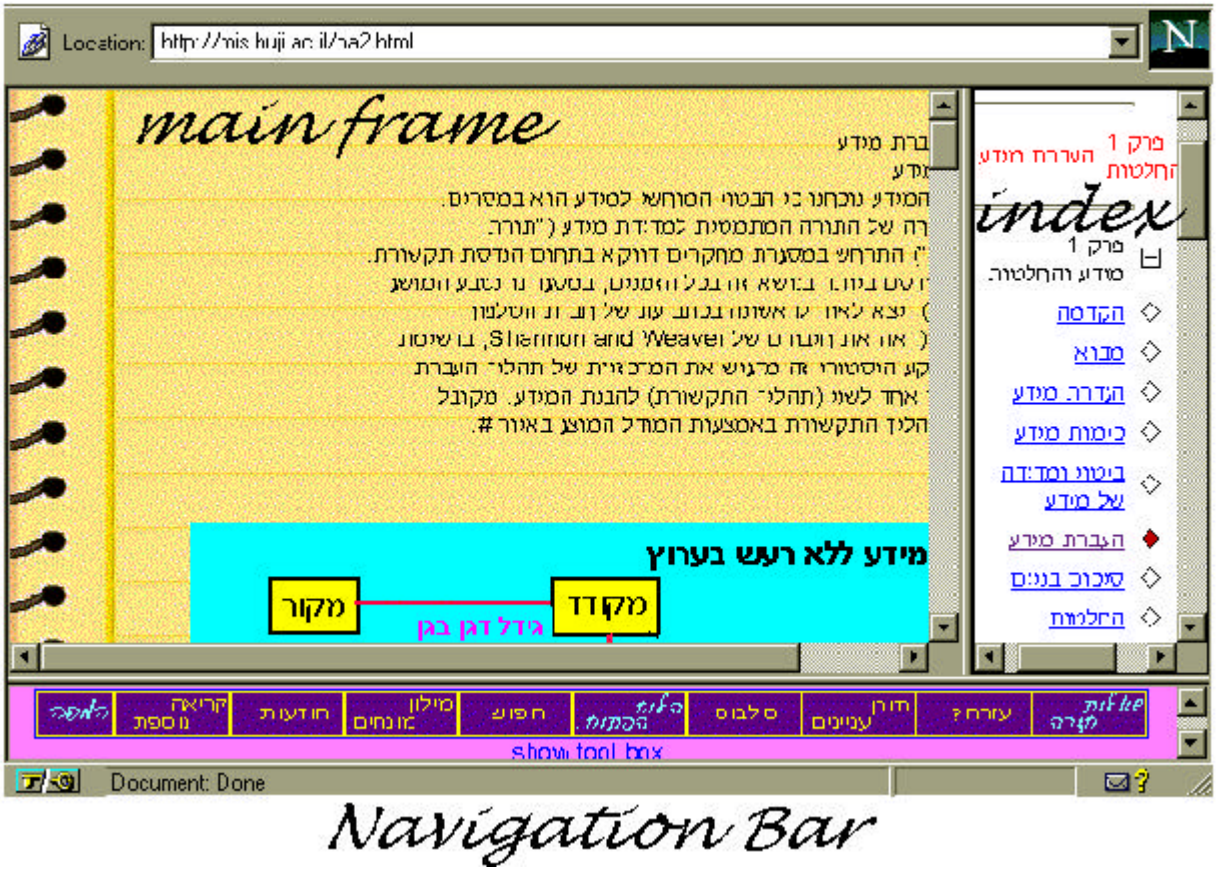

Illustration 1: Screen snapshot of the opening page.

The textbook contained just under 30 "nodes" (or pages) on average for each of the 9 chapters. Each node consisted of 2 to 3 pages (screens) of text, accompanied by static or animated illustrations in the GIF format. Each node ends with a pair of buttons/pointers to the following and preceding "page" (node) such that a student may browse linearly. A Javascript element loaded with each page ensured that the display in the table of contents highlighted an updated indication of the title and context of the page displayed at any given time in the main area. Each chapter ended in a collection of links. **Review questions**, in a true/false format, were made available for each chapter. Each batch of about 20 questions allowed students to voluntarily and interactively complete their answers. A CGI script graded and provided feedback and the correct answers. Each access to the review questions generated a textual and numerical response to the student, and was recorded in a special log. A special **glossary** was built, to summarize definitions of the concepts covered in the course. The glossary contained over 100 terms, explained in both English and Hebrew. Each definition was accompanied by a link to the more complete discussion in context in the "book". A **search engine** allowfull text, simple and complex boolean search of the entire system. **Homework assignments** included required exercises in searching the Web, trying out and proposing improvements for interactive decision support systems, proposing a strategic information system, and designing DFD and ER graphics. The homework assignments were also used as an opportunity to require students to read and react to each other's work, by basing later assignments on other students' earlier reports. An **open discussion board** allowed a-synchronous communication among students and between instructor staff and students. The board served for the submission of all homework, and the publication of grades. An average student posted a dozen messages to this board during the semester, including textual messages, hypertextual links, and graphics, such as the DFD and ER designs. The interactive board served as the meeting ground where students read each others' homework, and were required to react to other people's work. Two more recent additions to the tools included in the learning environment are a map and a note-taking system. The **map** displays a visual chart of the chapters and pages in the textbook. Each page is color coded to represent frequency and date of previous visits. At the touch of the appropriate button on the bottom "navigating" frame a student may receive a summary of what they've read and when. The map provides a navigation aid that is both spatial (in the text context) and temporal. Furthermore, students may also view a similar map displaying class averages, providing an online, virtual equivalent of social comparison. Also on the map page are summaries of earlier uses of the review question sections, and the results (grades) reached in trying these questions. The **notes** subsystem allows students to mark-up the text. The purpose is to personalize and internalize the system's content. Analogous to the yellow highlighting so prevalent in college-reading, this system combines icon marking with textual (written, typed) notes, that are fully searchable. Both the notes and the mapping systems are individual and dynamic, owned by- and relating to a particular student at a specific point in time. These latter two systems were developed only recently, hence not included in the data reported here.

Methodology

In the following we report on usage and performance by three classes during the winter of 1996/7. These are undergraduate (BA), graduate (MBA) and executive

MBA classes (see table 1). Students' final grade in the class was used as the primary performance criterion. The final grade was based on performance on midterm and a final tests, and six homework assignments. Each of the components (tests and assignments) were graded by different people. The Pearson product-moment intercorrelations among components of the final grade ranged between 0.5 - 08. Usage statistics include access to pages and usage of the further interactive (CGI-based) applications, such as search mechanism and review questions. The access log records were purged of irrelevant records, such as those reflecting use by instruction staff, providing a clean database of "Requests". We calculated a listing of student access paths (visits), arranged chronologically. A further statistical manipulation allowed the creation of a Markovian matrix of transitions. In this matrix, each line represents an "originating page" in the text. Each column represents a "target page". Each cell in the matrix expresses a probability for the transitions from a given page to another. After collapsing for some irrelevant pages, the matrix contains 90000 cells, (the square of 300 pages). The values in each row sum to 1, the sum of probabilities of transfer from each page to all other pages.

A measure of reading nonlinearity (NL) was developed. Nonlinearity is defined as the transition ("navigation") to a nonadjacent node. Nonlinearity was calculated as the ratio of the sum of nonlinear transition probabilities to the total number of pages (300). A value of zero on this measure expresses perfect linearity. A maximal value of one stands for a user who never read to adjacent pages. Stated formally: with $A_{i,j}$ cells in the transition matrix of j rows and i columns, the nonlinearity measure (NL) is

$$NL = \frac{\sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i \\ j \neq i+1 \\ j \neq i-1}}^{m} (A_{i,j})}{\sum_{i=1}^{n} \sum_{j=1}^{m} (A_{i,j})}$$

calculated as:

Usage and performance correlations were assesed via Pearson product-moment correlations for the individual components, and by regressing the overall (final) grade on usage variables.

Results

Less than half of the undergraduates have used the internet prior to the course (see Table 2). Among MBA students 56% have used the internet before the course. However, in both groups about 70% reported that they will increase use of the internet in their work and study in the future. About one third of the students "borrowed" usernames and passwords from classmates on occasion, a fact that sets upper limits to the reliability of access data. This phenomenon was significantly more prevalent among the MBA, graduate students. Home computing is widely diffused, with two thirds of the students reporting that they have a personal computer at home. Nevertheless, and despite the availability via the internet, more than half the accesses

to the system were done from the fairly limited computer laboratories at school. A very large proportion of the students opted to create and use hardcopy versions of the text.

TABLE 2: Student self-report questionnaire summary

Significantly different values appear in bold		BA	MBA
Number of questionnaires		81	66
Use only your own username?		**72.8%**	**69.2%**
Internet connection prior to course?	Yes	17.3%	33.3%
	Sometimes	23.5%	22.7%
Will you use the Internet in future?	Less	2.5%	3%
	No change	27.2%	27.3%
Have PC at home	Yes	63%	66.7%
Primary reading means?	From screen	24.7%	18.7%
	Printed	25.3%	21.7%
	Photocopy	50 %	59.6%

In a questionnaire distributed at the end of the semester, we asked students in the BA and MBA classes for their evaluations of the system. Overall reactions were positive, even despite the numerous frustrating technical obstacles. The graduate students were slightly more appreciative of the system, though the differences were not statistically significant. When asked whether they would prefer to have such systems incorporated in the remaining portion of their studies, 70% of the MBA students, and 55% of the undergraduates responded positively. In open-ended questions the most frequent complaint was that this course demanded inordinate amounts of students' time.

The original access log contained almost 140,000 records. Of these we purged 9 erroneous records, 2686 records dated earlier than the beginning of each class, 2162 non-course related accesses, 6433 instructors' accesses, and 15820 failed password attempts. The remaining requests are distributed as displayed in Table 3.

TABLE 3: Access log records

	BA	MBA	EMBA
Total # of requests Including graphics	21,700	14,487	10,573
Requests without graphics	15,434	10,114	7,736

Table 4 reports average and standard deviations of accesses per student, comparing the three classes.

TABLE 4: Summary of access log statistics

Significantly different values appear in bold	BA	MBA	EMBA

N (students) total in log	83	56	40
Average # page requests	170.9	169.25	152.79
std.	109.15	97.9	105.96
review questions			
Average # page requests	13.26	11.53	15.66
std.	12.2	10.65	11.06
Grades on review questions			
N (students)	66	41	26
Average grade (out of 100%)	63.6	**58.3**	**67.96**
std.	11.6	16.6	11.14
Search engine use			
N (students)	83	56	7
Average # of requests	0.27	0.5	**5.71**
std.	0.78	1.11	7.13

The three classes were similar in their use patterns. The only significant difference in use is in the amount of online searching within the system, which peaked for the EMBA class. The access records detailed in Table 3 were then used to create the transition matrices, as displayed in illustrations 2 - 5. Each content file ("page in the textbook") is represented by a column and a row in the matrix. Each column represents an originating file, and each row represents adestination file. Each cell stands for the probability of transitions from the originating page (column) to the destination file (row). The color coding for transition probability is as follows: No transitions (0% probability) is white. Up to 10% is coded yellow. 10-30% is coded red, 30-50% green, 50-70% blue, 70-90% purple, and 90-100% black.

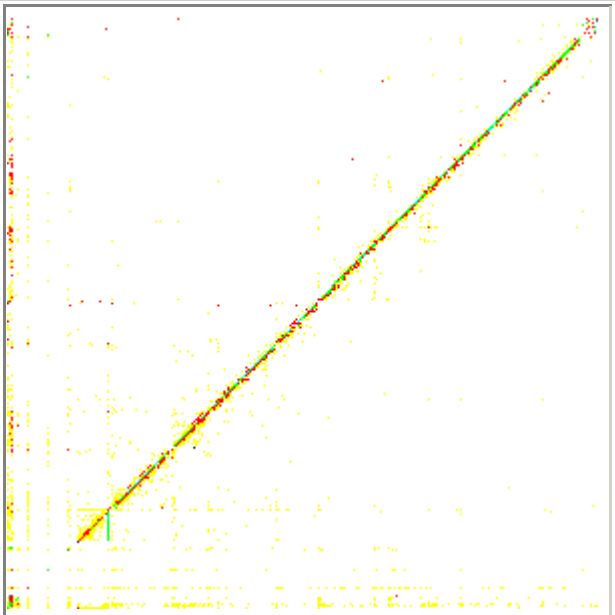

Illustration 2: Transition map, BA

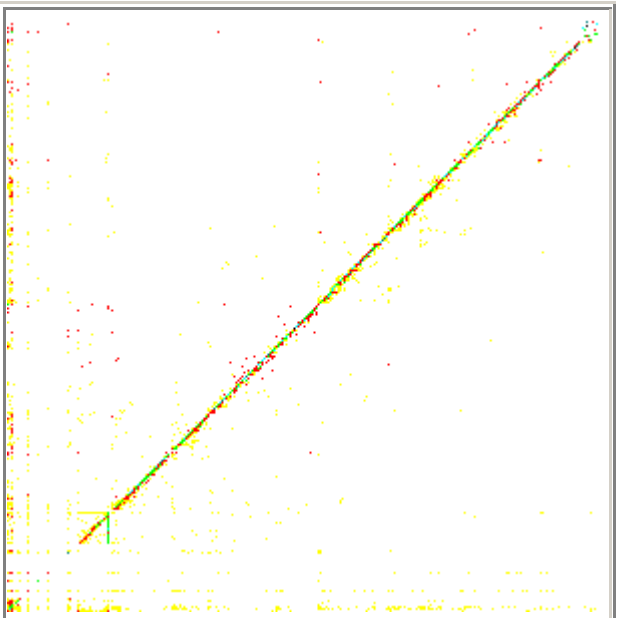

Illustration 3: Transition map, MBA

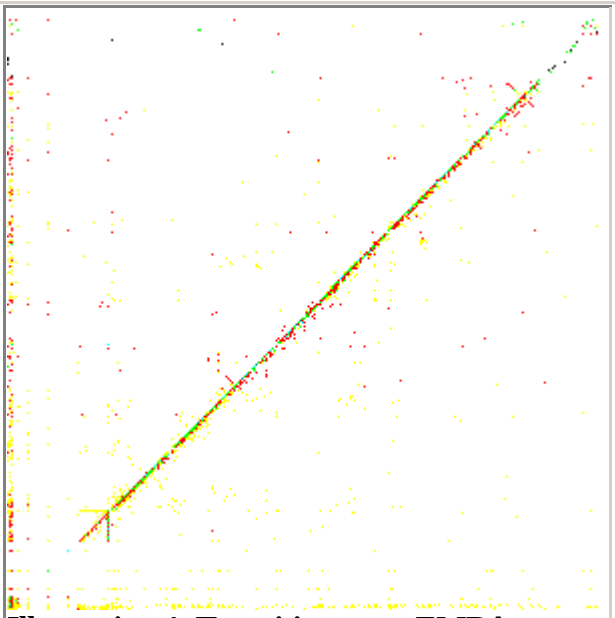

Illustration 4: Transition map, EMBA

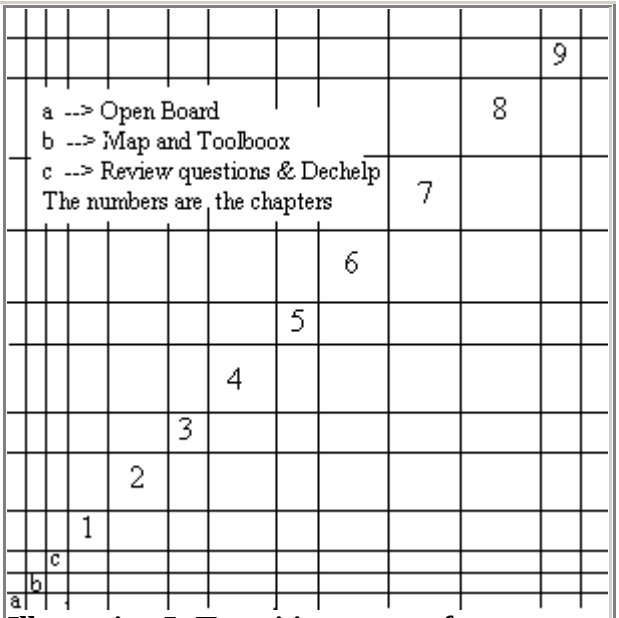

Illustration 5: Transition map, reference

Illustrations 2-5 indicate that most students tended to stick to the linear, traditional page-by-page order of reading material. The most heavily traveled path, the diagonal in these illustrations, was to read the textbook linearly, even though such use was not prescribed or even suggested. Clearly, too, the EMBA students were much more likely to diverge, and browse nonlinearly. The proportion of dots outside the main diagonal for this class is visibly larger. Also noticeable is the relative absence of linearity in the upper right hand corner in all three diagrams. This is the section representing the last chapter of the book, where the material is mostly a collection of legal documents, law, etc. This chapter was not taught linearly, and was not required for the test. There, too, students browsed in a less linear fashion.

TABLE 5: Non-Linearity averages per class. Standard deviations in parentheses)

NL(Standard div.)	BA	MBA	EMBA
The entire course	0.581 (0.101)	0.585 (0.099)	0.621 (0.088)
Only the textbook	0.570 (0.220)	0.593 (0.185)	0.622 (0.149)

The Non-Linearity measure (NL) displayed in Table 5 is a summative expression for the probability of moving between pages in a nonlinear fashion. A higher value on this measure indicates less linear reading, and more "purposive" browsing, using hypertextual links, searches, table of contents, glossary and index navigation. An analysis of variance test for the differences between the classes shows that the differences are significant. Post -hoc paired comparisons show that only the EMBA group differs significantly from the other two groups on reading the entire course.

TABLE 6: Correlations matrix between final grade

BA(N=84) MBA(N=56) EMBA

(N=38)					
Final Grade	**Grades on review questions**	**Requests for review questions**	**Requests discussion board**	**All Requests**	
Grades on review questions	**0.1953** **0.2499** 0.1103				
Requests for review questions	0.1611 0.0813 0.1229	***0.6924*** ***0.7267*** ***0.7069***			
Requests for discussion board	**0.209** **0.2286** **0.3034**	***0.3487*** ***0.4056*** 0.1708	***0.389*** **0.293** **0.3089**		
All Requests	**0.2461** **0.2849** **0.3428**	***0.4907*** ***0.5602*** ***0.395***	***0.4995*** ***0.5042*** ***0.5299***	***0.859*** ***0.827*** ***0.879***	
Requests textbook only	0.2147 **0.2672** **0.2853**	***0.4123*** ***0.4601*** ***0.441***	***0.3345*** ***0.4129*** ***0.4886***	***0.545*** ***0.490*** ***0.472***	***0.888*** ***0.887*** ***0.826***

Note: Significant correlations ($p<0.05$) are displayed in **boldface**,

significant correlations ($p<0.01$) are displayed in both ***boldface and italics.***

Table 6 indicates very high positive linear correlations among the use behaviors, and significant modestly positive linear correlations between the final grade and each of the usage behavior measures. This pattern replicates reliably across classes.

The final grade (paper-based tests and homework assignments) was regressed on a logarithmic transformation of the usage score (how many pages people read) and of the online review questions grade. Results of this regression are displayed in Table 7.

TABLE 7: Multiple Regression of Final Grade (dependent variable)

on logarithmic transformation of usage and online review questions grades (independent variables)

	BA	**MBA**	**EMBA**	**ALL**
Multiple R	0.544	0.452	0.682	0.487
R Square	0.295	0.204	0.465	0.237
Adjusted R Square	0.270	0.155	0.383	0.222
F	11.561	4.124	5.66	16.48
Signif F	0.0001	0.255	0.171	0.000

Actual usage and average grade on the optional online review tests were entered into a regression model to predict the final grade. The independent variables were transformed, using the natural logrithmic function, to highlight the role of low and medium use and to compensate for the overstated effects of very heavy use or top grades. The regression model results are that the findings when the linear correlation was used are even more pronounced. The independent variables (use) predict upwards of 20% of the variance in the dependent variable, final grade.

Discussion

This is a study of the design and effectiveness of a Web-based learning environment. The environment was developed keeping in mind the five dimensions of synchronicity, mutlimedia, interactivity, packet-switching and hypertextuality. The first observation is that an online, web-based learning system is feasible, and worked well with three large classes of varying levels. Of course employing online techniques for an MIS introductory class is desirable as an instance of the subject matter ("cobblers not going barefoot"). But the online tools enable more than just "doing as we preach". Our results indicate that at least some of the goals we set for ourselves are obtainable, that there is an acceptance of such tools among students, that the use of such tools engenders more openness to the use of other online tools, and that there is a correlation between amount of use and performance using the system and external learning criteria. A respectable proportion of the variance in an externally assessed final grade can be (at least) predicted by unobtrusive measures of online usage. This finding is even further bolstered by the fact that a large portion of the students read the material offline, limiting in advance the variance in the predictor variables.

We have also learned (or validated earlier findings) about limitations and need for further improvement. We learned that many students will still resort to offline reading, when given the option. We learned that creating an online environment is not just a matter of pouring formerly linear content into a hypertextual container. Nonlinearity is a goal that requires striving, and its level is an indication of the students' nature. Like Andres (1994) and Schutte (1997) our students found that they devote more time to this course than they expected, and than is customary. This finding is related to predicted correlates of interactive systems (Rafaeli, 1988, Newhagen and Rafaeli, 1996). Is spending more time on a course a positive or a negative outcome?

This evaluation study was unobtrusive. It made use of automatically accruing access logs as the main source of evaluation data. As such, our results are non-experimenetal. We have no controls built into the data collection phase, students were not assigned randomly to "treatments", and there are alternative possible explanations for the findings. This is the greatest limitation of this study. The direction of causality cannot be determined, and we must reserve our interpretations. It might very well be that the correlation between access log data and final grades is an indication of better students using the system, rather than of the system making better students. However, even this minimal interpretation of the results is favorable, in the sense that this sort of an online system serves the needs of more advanced students. Furthermore, the fact that the cumulative average score on the voluntary review questions correlates with the final grade too, places more weight on the first causal interpretation of the correlations.

The three classes shared a common subject matter but differed in number, length and frequency of lectures, and the availability of in-lab tutorials. Mostly, though, the classes were distinguished by the nature of their students. The three classes can be rank ordered on the "experience" dimension. Younger undergraduates lack both the academic and the employment/real world experience their elder graduate student counterparts have. The Executive MBA students are even more mature. Consequently, undergraduates received more instruction hours and more individual tutoring. The three groups did not differ in how they used the system, with the exception of the search mechanism that was used more extensively by the EMBA group. The average stread about 160 pagesonline. However, the groups did differ significantly in the linearity revealed in their reading. The more mature EMBA students made more nonlinear use of the resources available. We tend to interpret nonlinear use as better, and would like to ascribe the difference to maturity (see also Hart, 1996 on this issue).

We found the use of asynchronous discussion groups to vary between the groups as well. The EMBA students made more use of the discussion system for in-group discussions of the study materials. Everett & Ahern (1994) suggested that experience with human to machine communication is an imported skill. This datum tends to support their observation. It also suggests that online systems such as intranets which students are likely to encounter in the real world will require adjustment, that such systems could be good practice, and that the implementation of online learning systems may be easier among more mature audiences, and may require more preparation for younger undergraduates.

Many of our findings need to be taken cautiously for another reason. The use of online learning systems is still a novelty. This results in caution on the part of students, and reflects growing pains of first-time-runs. Some of the system components are still under development. We had numerous system and communication crashes for the first months of the system life-cycle. Dealing with a non-English language on the Web imposes yet another layer of complexity on designers, maintainers, and students. Yet, novelty has its positive sides as well. In an environment of rapid change, there is no doubt we will see accelerating use of new technologies in learning. It is doable, and in the field of information systems, it is advisable too. Further work is needed on designing online implements to allow teachers to collaborate in teaching similar courses. Another area for future work are further applications of the availability of access logs generated during the use of online materials. For instance, we are currently working on the merging of navigation aids and access logs. Will better, dynamically updated navigation aids enhance browsing, and will that, in turn, add to the learning experience?

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