Active Learning Centre: Utilization Patterns of an Interactive Educational World Wide Web Site

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The advent of the World Wide Web (WWW) provides unique opportunities to transform medical education. Interactive computer assisted instruction has shown promising results but its growth has been impeded by logistical barriers. We designed an interactive WWW site – Active Learning Centre (ALC) - that offers a novel approach to these problems, combining remotely authored databases with computer-generated self-assessment tests. This study analyzes utilization and user assessment of the site.

The site was found to be patronized mostly by students and health professionals from English-speaking countries. Users have been pleased with their experience and suggest further expansion of the ALC. Our data have also tentatively shown that their knowledge improved with repeated visits to the site.

INTRODUCTION

Over the eight years since it was born, the growth of the WWW has been explosive. According to a recent report by Computer Industry Almanac, there were 147 million Internet users worldwide at year-end 1998 – up from 61 million at year-end 1996[1]. Overall growth in health-related sites has been comparable[2]. However, medical educators have not taken full advantage of the opportunities offered by this medium. Interactivity has been shown to be a crucial element of the learning process[3]. However the majority of medical education sites function as passive repositories of information with little if any user interaction, and they are also frequently limited in scope. There are objective reasons for these deficiencies. Designing questions to provide feedback to the user is usually a very labor-intensive process – for example, the National Board of Medical Examiners guide to constructing written test questions is 125 pages long[4]. Exponential growth of medical information requires contribution of numerous experts to any publication that aims at a wide scope of coverage – the last edition of Harrison's Principles of Internal Medicine has no fewer than 375 authors[5] – requiring devotion of significant resources to the administrative tasks.

Faced with these obstacles, we have developed a conceptually new structure of an educational web site. The key features of the proposed design are:

- Support of potentially unlimited number of searchable databases – each dedicated to a separate topic
- Computer-generated customizable feedback tests
- Remote WWW-based database authoring (enabling input from outside experts)

This scheme was realized in Active Learning Centre (http://www.med.jhu.edu/medcenter/quiz/home.cgi). This paper presents a study investigating utilization patterns of the web site as well as users' demographics and expectations.

METHODS

Data Structures

ALC can support an unlimited number of databases (Figure 1), each of them devoted to a specific topic (currently available databases include Microbiology, Pharmacology, Vaccines, and Cardiovascular Medications). The databases store information in a uniform object-oriented format; each object (e.g. a drug or a microorganism) can have an unlimited number of attributes, both single- and multi-valued. Each of the databases is created and edited by its author, using WWW-based tools requiring no knowledge of programming languages or even HTML. All of the ALC tools (described below) can be used with any of its databases. The data can be in (potentially) any language; currently supported languages are English and Spanish.

All current data in the Microbiology, Pharmacology and Vaccines databases were entered by one of the authors (AT). No formal validation of the content was performed but users were encouraged to submit criticisms. The data in the Cardiovascular Medications database was entered by Rodolfo Chaj, M.D., - a faculty member at University of Buenos Aires School of Medicine.

ALC Tools

ALC is comprised of several CGI programs (Figure 1):

a) the gateway script (home.cgi) introduces new users to ALC and provides access to all ALC tools and databases

b) the object presentation script (objPresent.cgi) fetches information on specific objects from ALC databases

c) the database query script (objQuery.cgi) allows users to run keyword queries against ALC databases

d) the quiz generator script (quiz.cgi) composes customizable tests using data stored in any of the databases. Users can request different types of questions (e.g. multiple choice, matching, essay), select which features of the database objects to be tested on (e.g. only on indications and side effects of drugs), or limit the test to a predefined subset of objects (e.g. only bacteria but not fungi or viruses). Users can also vary the number of question asked at a time and choose whether or not to keep score of correct / incorrect answers.
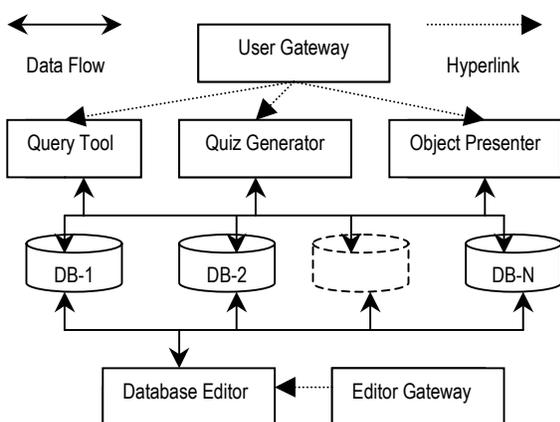

Figure 1

Data collection

The sample for the study was the group of ALC users from 01/14 to 02/14, 1999. Three main categories of user information were collected in the course of the study: user demographics, their utilization of the site's functionalities, and their evaluation of the site.

User demographics were obtained from the entrance questionnaire presented to patrons after they attempted to access an ALC tool script from within ALC site (to limit the data to patrons who already familiarized themselves with the site and were genuinely interested in using it). The questionnaire consisted of seven items: user self-description, country, speed of Internet connection, number of times the user had accessed ALC before, how the user found out about ALC, his/her purpose of using ALC, and optional comment space. After nine page requests (giving patrons sufficient time to acquaint themselves with ALC) they were given a follow-up questionnaire, which asked them to rate ALC's accuracy, completeness, utility, ease of use, and

speed on a Lickert scale from one (worst) to five (best), and again provided comment space. Users could defer filling out either of the questionnaires by requesting a "timeout" (24 hours) or permanently disable them by stating that they have already filled out the questionnaire previously. The page with the entrance questionnaire included a brief description of the study and its goals; by filling out the questionnaire and proceeding to use the site, patrons consented to participate in the study.

Individual user machines were assigned unique ID numbers for the period of the study by the means of HTTP cookies; host names were also recorded as a backup in case user's browser was not accepting cookies. This allowed for persistent tracking of users' utilization patterns from session to session and association of individual patterns and demographics; it also prevented patrons from being presented with questionnaires more than once.

Software / Hardware

ALC consists of several Common Gateway Interface (CGI) scripts written in Practical Extraction and Report Language (Perl). It is based on a Sun UltraSparc® II workstation, running SunOS 5.6 and Apache HTTP server version 1.3.

RESULTS

Data validation

Over the study period, 73% of 655 patrons who were asked to fill out the entrance questionnaire, and 61% of 174 patrons who were asked to complete the follow-up questionnaire, submitted some or all of the requested information. Seven (1.5%) entrance and three (3%) follow-up questionnaires were invalidated due to inappropriate answers.

ALC utilization patterns of users who filled out the entrance questionnaire were compared with those of users who refused to do so (i.e. requested a timeout) to ensure that the questionnaire data could be generalized to the entire patron population. Statistically significant difference between the two groups was observed only for the mean number of hits (28 for responders vs. 16 for non-responders, $p < 0.01$) but not for the relative amount of time spent on each of the databases or fraction of questions answered correctly. Similar analysis was performed for the follow-up questionnaire, where statistically significant differences were observed for the mean number of hits (72 vs. 45, $p<0.05$) and fraction of correct answers (50% vs. 42%, $p<0.01$) but again not for relative usage of different databases.

User demographics

Over the study period, 1855 patrons visited

ALC. Of the 404 users (84% of those who completed the entrance questionnaire) who chose to answer the question about their self-description , college students were the most prevalent (at 20%) followed by medical students (17%) and microbiologists (11%). Patrons came from 69 countries, most commonly the U.S. (59%), Canada and the U.K. (5.5% each).

Utilization of the site

13% of patrons had used ALC before; one fourth of the repeat users had used it more than 10 times. When asked about the reason for visiting ALC (more than one answer was possible), 35% of the users indicated that they were studying for a test, and 32% were using it as a reference or an independent learning tool. 50% of patrons mentioned curiosity as their reason to visit the site. As expected, students were the most likely to be using ALC to study for a test (67% of pharmacy students and 61% of medical students did). Notably, high frequency ALC users were much more likely to mention independent studying / reference as their reason to visit ALC (77% of those who had used it more than 10 times).

The range of the number of requests per user was wide: while 60% of the patrons accessed ALC only once, the most avid users registered as many as 5,000 requests over the study period. Patrons, who indicated in the entrance questionnaire that they had visited the ALC prior to the study period, accessed ALC on average more than twice as many times as first-time users (60 vs. 26 requests) during the study interval. Microbiologists had by far the most interactions with the server, averaging 72 requests; they were followed by fellows (35 requests) and physicians (32 requests). Patrons reporting using ALC for independent studying / as a reference requested more pages (39) than those using it either to study for a test (27) or out of curiosity (26).

Among ALC tools, the quiz generator was used most frequently – over the course of the study patrons requested over 20,000 questions (on average 11 for every user) and accessed object presentation and query tools over 800 times each. Choosing between different question types, users almost unanimously voted for multiple choice questions, which comprised about 99% of all questions requested.

The learning curve

Overall, patrons answered 49% of questions correctly. However, performance differed between user groups: of those, represented by more than 10 users, microbiologists were the most knowledgeable (73% correct answers), followed by physicians (70%) and pharmacists (63%). Users who were visiting ALC to study independently or to use it as a

reference, showed much better results (67% correct) than those who were simply curious (52%) or were studying for a test (40%).

Notably, patrons who stated that they had used ALC in the past had significantly better results than novices – 78% correct answers for those who had used it more than 10 times vs. 49% for the first time users (Figure 2). On the other hand, there was no clear correlation between the total number of requests over the study period and the average fraction of correct answers (correlation coefficient 0.06).
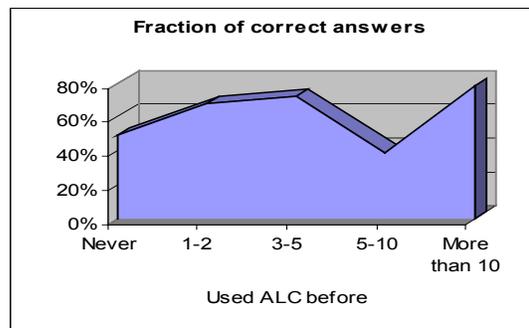

Figure 2

Customer feedback

In order to improve the ALC according to user needs and demands, it was important for us to determine what the users thought of their experience with the site. The results of the follow-up questionnaire, offered to patrons after they accessed the site at least nine times, were encouraging. All average ratings, on the scale from one (worst) to five (best) were above 3.5; ALC fared worst in completeness (3.57) and best in ease of use (4.2).

Issues raised by patrons' free-text comments were manually classified into the following categories: requests for more databases (i.e. more subjects), requests for broader coverage within existing databases, requests for more features / tools, corrections, and praise (one comment could be classified into several different categories). While half of all users submitting relevant comments offered praise, many suggested further areas of improvement (Figure 3).

Comment category	% of all comments
Praise	50%
Broader coverage	29%
More databases	21%
More features	9%
Correction	3%

Figure 3

DISCUSSION

Since Socrates, it has been well established that interactivity and feedback are key components of the learning process[3]. However, until recently few media offered students a full-fledged interactive experience. Textbooks and videos only provide a unidirectional flow of information; lectures are slightly better but the usually large number of students limits effective communication between pupils and the instructor; small group sessions seem ideal but consume too much expensive human resources. With the advance of personal computers came computer-assisted instruction (CAI), and a number of these systems showed results superior to that achieved by traditional forms of teaching[6]. However, most of these programs are expensive and out of reach of a typical student budget[7]; keeping them current would require frequent re-installations of each of them on a user's PC – a cumbersome process few would want to endure. WWW, however, is unique in that it provides an effective and inexpensive information delivery medium with simple uniform interface allowing easy centralized updates – an ideal environment to build educational software.

While some people have voiced concerns about the possible barriers to the WWW integration into medical education[8], most of these issues are being resolved as network access rates, access to computers with WWW browsers and integration of CAI into medical school curricula are improving[9,10]. One important problem that still needs to be addressed, however, is the design of WWW educational technology[11]. As has been correctly pointed out, a consumer-oriented approach to evaluating educational software is important[12]; surveys of user opinions and their utilization of educational WWW sites are thus crucial to the process of developing CAI tools.

Unfortunately, such studies are scarce, and most of them evaluate sites whose main function is passive information transfer[13,14]. To our knowledge, this is the largest study to date of an *interactive* medical education WWW site.

As expected, students were significantly more prevalent (60%) in our patron population than in other medical WWW surveys[15,16] However, only half of them were studying a health-related field; 50% were either high school or college students and reported using ALC mostly out of curiosity. A quarter of users were health professionals, more than a third of whom were using the site for continuing medical education or as a reference. When compared to the results of a recent Internet user survey[1],

English-speaking countries (U.S., U.K., Canada) were somewhat over-represented, and a number of major non-English-speaking countries (Japan, Germany, France) were significantly under-represented. This demonstrates the necessity of expansion of ALC multi-language capabilities (beyond the existing Spanish) to make it a truly universal educational resource.

Among the available tools, the quiz generator was by far the most popular, confirming patrons' preference for interactive learning process.

As expected, users visiting ALC to study independently were the most motivated, registering the highest number of requests and also reporting the highest frequency of using ALC in the past – after all, tests come and go, but the need to continuously update one's medical knowledge remains.

In general, users who have visited ALC previously performed better than novices (78% correct answers for those who had used ALC more than 10 times vs. 49% for first-time users), offering indirect evidence that patrons learned from the WWW site. This finding is unlikely to be an artifact of users simply memorizing the questions (we estimate that the quiz generator is can generate thousands of unique questions from its databases). It could, however, have other explanations, such as that the repeat users, being more motivated, might have learned more in the past from other sources. More rigorous research would therefore need to be performed to definitely answer the question of ALC efficacy.

In their evaluations patrons appeared satisfied with the general setup of the site, giving it 4.2 out of 5 for ease of use and offering a positive assessment in 50% of free-text comments. A number of them, however, commented on the need to expand coverage of existing databases and to establish databases on other topics – a concern that will be taken into account in further ALC development.

Ours being an imperfect world, this study's methodology was not completely flawless. Since cookies / host names served as identification tags, computers rather than individual users were the units of the study. This would result in artificially high number of requests from shared computers and lower number of requests from users using several computers (e.g. at home and at work). On the other hand, in the former case the patterns of use would be expected to be comparable from all users since their profiles would likely be similar (e.g. medical students in a computer lab).

User evaluations for the follow-up questionnaire were solicited after only nine requests to maximize the amount of data collected; this could,

however, adversely affect the validity of assessments submitted after only a brief experience with ALC.

Finally, when patrons who filled out the study questionnaires were compared to those who did not, their utilization patterns were different in some respects, including the total number of requests and fraction of correct answers, though not in database / tool usage. It is thus possible that our findings cannot be generalized to the entire user population.

CONCLUSION

This study represents the first major effort to date to analyze utilization patterns and user assessments of an interactive medical educational WWW site. Overall, patrons were pleased with the site; most common request was for its further expansion. This confirms our premise about the need for interactive educational tools on the WWW. It shows ALC paradigm of remotely authored databases and computer-generated self-assessment tests to be effective, as well as points out the direction for further growth.

ACKNOWLEDGEMENTS

References:
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1. Computer Industry Almanac, Inc. February 1999 press release, available at http://www.c-i-a.com/199902iu.htm. Cited 2/17/1999.
2. Sonnenberg, FA. Health Information on the Internet. Archives of Internal Medicine. 1997; 157:151-152.
3. Sachdeva AK. Use of Effective Feedback to Facilitate Adult Learning. Journal of Cancer Education. 1996 (11); 106-108.
4. Case SM, Swanson DB. Constructing Written Test Questions for the Basic and Clinical Sciences. 2nd edition. Available at http://www.nbme.org/new.version/item.htm. Cited 12/17/99.
5. Fauci AS, Braunwald E, Isselbacher KJ, et al., editors. Harrison's Principles of Internal Medicine, 14th edition. New York: McGraw-Hill; 1998.
6. Fletcher-Flinn CM, Gravatt B. The Efficacy of Computer Assisted Instruction (CAI): A Meta-Analysis. Journal of Educational Computing Research. 1995; 12(3):219-242.
7. Stocking JE, Mo BP. Current Status of Interactive Multimedia Education in Medicine. M.D. Computing. 1995; 12(5):373-381.
8. Friedman RB. Top Ten Reasons the World Wide Web May Fail to Change Medical Education. Academic Medicine. 1996; 71:979-981.
9. Lowe HJ, Lomax EC, Polonkey SE. The world wide web: a reviw of an emerging internet-based technology for the distribution of biomedical information. Journal of American Medical Informatics Association. 1996; 3(1):1-14.
10. Ruskin KJ, Doyle DJ, Engel TP. Development of an academic internet resource. Yale Journal of Biology and Medicine. 1996; 69(5):439-444.
11. Wang MJ, Contino PB, Ramirez ES. Implementing cognitive Learning Strategies in Computer-based Educational Technology: A Proposed System. Proceedings: AMIA Annual Fall Symposium. 1997:703-707.
12. Glenn J. A Consumer-Oriented Model for Evaluating Computer-assisted Instructional Materials for Medical Education. Academic Medicine. 1996; 71(3):251-255.
13. Graber MA, D'Alessandro DM, D'Alessander MP, et al. Usage analysis of a primary care medical resource on the internet. Computers in Biology and Medicine. 1998; 28:581-588.
14. Bittorf A, Bauer J, Simon M, Diepgen TL. Web-Based Training Modules in Dermatology. M.D. Computing. 1997; 14(5):371-381.
15. Lehmann CU, Wang DJ, Kim GR, Johnson K. Utilization of a paediatric link collection by health professionals and laypersons. Medical Informatics. 1998; 23(1):53-62.
16. Health On the Net Foundation. Health On the Net (HON): Survey Feb/March 1997 – Results. Available at http://www.hon.ch/cgi-bin/quest/quest_internet. Cited 2/17/1999.