Cost Efficient Management of Educational Material

Christopher Cimino, M.D.†, Joseph Reichel, M.D.§, and Marjorie Serrano•

†Office of Computer Based Education, §Department of Medicine,

and •Office of Instructional Support Services

Albert Einstein College of Medicine, Bronx, N.Y.

We retrospectively examined direct and indirect costs of providing a programmed text in Respiratory Pathophysiology using World-Wide Web (WWW) technology as compared to printed paper. The direct costs were $3678 and $3988 respectively. Neither of these costs includes the substantial cost of original development of the educational material. The indirect cost of distributing printed material is $1800. The indirect cost for electronic material is $1430 but this assumes an institutional commitment to a technology infrastructure which will be used for purposes other than just educational material distribution. Given such a commitment, educational material can be managed in a way that provides efficient distribution at less cost than traditional paper distribution. The effectiveness of electronic methods is dependent on usage. A comparison study of use and satisfaction of paper and electronic versions of the material is planned.

INTRODUCTION

The World Wide Web (WWW) (1, 2) has shown itself to be an useful tool for distributing a wide variety of information. It is also flexible enough to be useful as a method of self-evaluation and of collecting information. The majority of medical materials available on the WWW consist of image collections or the conversion of existing linear written material to hypertext (3-5).

Programmed texts represent an attempt to create written texts that are not linear. Studies have shown that programmed texts can be as effective as computer aided instruction (CAI) and have suggested that their low costs raise doubts about the need for CAI (6, 7). However, with few exceptions (8), programmed texts have not been successful in replacing either CAI programs or traditional textbooks. One reason suggested for this lack of acceptance is that while programmed texts provide instruction suited to a student's need at a certain point in the material, they do not allow the student easy entry into the material to cover specific points of interest the way a traditional indexed textbook does (9, 10). The AECOM course in respiratory pathophysiology has used a printed programmed text (11) which has now been adapted to the WWW. This gave us the opportunity to revisit the issue of cost comparison.

METHODS

Materials

The 1973 version of the programmed text of Respiratory Pathophysiology consists of 243 pages divided into 4 sections (COPD — 76 pages, Respiratory Failure Part I — 84 pages, Respiratory Failure Part II — 79 pages, and Asthma — 24 pages). No electronic version of the text existed. The first step was to produce an electronic version of the text. The original copies available were not of sufficient quality to allow scanning and optical character recognition so a temporary worker was hired to enter all the text. Graphs and tables were reproduced using a drawing program. Nomograms and "real data" graphs were scanned and then traced in a drawing program. Gross and microscopic images were scanned from the original text and edited in a photo editing program.

The next step was to edit the text for content accuracy. Only the first three sections were planned for distribution since the Asthma section required major content revisions. A paper version of the first three sections was printed for editing. After the first pass of editing by the content expert (Dr. Reichel), corrections were made to the electronic version and the document was converted to a pseudo–HyperText Mark-up Language (HTML) format by the HTML expert (Dr. Cimino). A macro was then used to produce a new word processor document which was printed and re-edited by the content expert. Editing was repeated on each section until the content expert was satisfied (3-5 passes) and the final word processing format was then sent to the Office of Instructional Support Services (ISS) for duplication and distribution to the students. The pseudo-HTML format was also converted by macro into a final HTML format which was distributed via the WWW.

0195–4210/95/$5.00

The current specification for HTML does not support the use of subscripts, superscripts, or non-standard symbols. Graphics of symbols and subscripted text were collected (e.g. CO_2 and $\overset{\bullet}{V}_A$). A macro was written to scan the file for special sequences and substitute HTML references for the special sequence graphics.

Another problem with HTML is that there is a trade-off between performance and document management. It is much easier to edit one large document and maintain internal consistency. HTML allows the use of local hypertext links within a single document but transferring such a document can be prohibitive. Each of our three sections, with all included graphics, figures, and tables ranged in size from 5 to 8 megabytes. The same end result can be achieved by having multiple small documents with external hypertext links between documents. A macro was developed which recognized a locally developed HTML extension for defining "sections". A HTML code for sections is recognized by the macro which then splits the file into multiple files. The macro also changes the local address links in the single large document into external file address links between documents. This approach allows for efficient editing of the entire file while allowing efficient network access to sections of the file.

Cost Phases

The development of the material for distribution was divided into three phases. The first phase consisted of revising the programmed text from its 1973 version. The second phase involved producing and distributing the paper version of the material. The third phase occurred concurrently with the second phase and involved producing and distributing the computerized version of the material.

Direct Costs

Phase one costs included part-time secretarial support, printing costs for draft versions (at 5 cents/page), estimated time spent editing by the content expert, estimated time spent creating graphics by the HTML expert, estimated time spent creating tables by the HTML expert, and estimated time spent transferring edits on the paper version to the electronic version by the HTML expert. Phase two costs included printing of the final draft and duplication for the medical students and faculty (200 copies). Phase three costs included estimated time spent scanning, converting the first electronic version to pseudo-HTML, writing HTML macros, transferring HTML and graphic files to a WWW server, and testing WWW code. Estimates for the HTML expert were based on a log kept concurrently as part of an educational dossier. Estimates for the content expert were based on self reporting.

Indirect Costs

We did not examine indirect costs such as heating, lighting, or space. Our primary interest was in the cost to distribute materials through mechanisms that were already in place for other purposes. There were no phase one indirect costs. Indirect costs for phase two were the time spent by the staff of ISS in distributing the material. This office has primary responsibility for distributing course materials to first and second year students. This office also has responsibility for scheduling classrooms, administering exams, distributing exam results, and maintaining (non-computer) educational facilities. The office employs 3.5 full-time equivalents (FTEs) and manages 28 distinct courses for 352 students. Phase three indirect costs include the cost of maintaining computer facilities for the students which is the responsibility of the Office of Computer Based Education (CBE). These facilities include 45 public machines connected to the network which provide access to educational and productivity software (e.g. word processing, statistics). These facilities are shared by the Sue Golding Graduate Division (approx. 90 students) and the Ferkauf School of Psychology (approx. 65 students). The Office employs 2.5 FTEs and has an annual equipment budget of approximately $80,000.

RESULTS

The measured direct costs for producing and distributing this course material are shown in Table 1. Additional estimated direct costs are shown in Table 2. The total measured and estimated direct costs for Phase I were $2778, costs for Phase II were $1210, and costs for Phase II were $900. This gives an estimated direct cost for revising and distributed the paper version (Phase I + Phase II) of $3988 and for the electronic version (Phase I + Phase III) of $3678. If no revision is needed in year 2 then the direct costs for paper distribution is fixed at $1210 and the direct cost for electronic distribution drops to nothing.

The method of estimating the indirect costs is shown in Table 3. The difference in average base salary is a reflection of the difference in staff training: secretarial support versus computer maintenance support. While

ISS does incur equipment costs, none of this equipment is used in the distribution of paper course material. In contrast, all the equipment costs of CBE are involved in the distribution of material. The proportion of support devoted to distribution of material is based on the average time reported by the staff of ISS. For the CBE the proportion is also based on self reporting, but these estimates are supported by student usage questionnaires (15% instructional use) and analysis of sample usage logs (18%).

DISCUSSION

The results of this study are easily generalizable to other projects and other institutions. Direct costs can be related to the size of the material. For paper distribution this is almost entirely duplication costs. For the entire student body (176) the cost is $6.05 per page of the original manuscript. Electronic version is also related to the size of material but is independent of the size of the student body. Electronic costs came to $4.50 per page. This suggests that electronic distribution will be more efficient for class sizes above 130, but this will be greatly affected by the number of images in the material and does not include indirect costs. Indirect costs will be less affected by class size. As described below, the indirect cost calculations will be affected by institutional goals. If the institution plans to make computers available for other purposes, this lowers the indirect costs. Because of our institutional goals, electronic distribution would remain more cost efficient for a class size as low as 100.

An obvious problem with this study is its reliance on estimates of time spent by the content and HTML experts. Inaccuracies in the content expert's estimates contribute only to Phase I costs so errors in estimation will not change the cost difference between paper versus electronic material. The HTML expert's estimates are more problematic since they represent the only direct cost of Phase III. These estimates were based on data entered into an educational dossier being kept for promotion purposes. This would probably bias the total effort (34 hours) to be an over-estimate.

The four main tasks involved in the 34 hours were 1) transcription of edits made on paper into the electronic version, 2) scanning and creation of figures and tables, 3) conversion of the word processor file to pseudo-HTML and 4) creation of two macros. Errors in estimate of transcription time would effect Phase I costs and would have no net effect on difference in total costs. It could be argued that scanning of the 22 images and creation of the 75 line drawings and 4 tables were not necessary for the paper version. Copies of these 101 items from the original illustration could have been cut and pasted into the final document. Creation of the electronic items averaged 11 minutes per item. Cutting and pasting would probably have taken less time per item but would have to be redone if any future revisions are made to the text.

The conversion of the document was done mostly with global changes of word processor style codes to HTML codes. Because of the regularity of the program text, even address links and sections could be created this way. Viewing the converted document with an HTML browser quickly showed the location of most errors without the need to read the text. The two macros each represented about 80 lines of code. It would require a 40% error in the Phase III estimates to make total direct costs equal for paper and electronic materials.

It is important to note that ISS costs are usage-driven while CBE costs are infrastructure-driven. In other words, an increase in demand for ISS services would require a proportional increase in ISS support costs. An increase or decrease in demand for CBE services would not necessarily result in a change in CBE support costs. This is in part because the CBE costs exist whether or not the equipment gets used. Another way to look at this is that the use of the equipment for word processing and e-mail subsidized the educational use. If a school has already committed itself to providing these services to students, then providing electronic educational material is cost-effective as compared to providing paper material.

The key point which this study does not address is how useful the students find the electronic material. As a programmed text, one could predict that the material is better suited to computer presentation than paper presentation. Anecdotal comments from some students indicate that the electronic version of the material was "easier to use" than the paper version. However, all these reports were from students with prior computer experience. "Ease of use" will also be offset by decreased accessibility of computer materials compared to paper.

The accessibility of the electronic material was also limited to computers connected to the Internet. Some students purchased their own Point to Point Protocol (PPP) accounts (approximate cost $240/year) to gain access to this and other educational material available

through the WWW. Providing the material this way significantly changes indirect costs for Phase III. On the one hand, word processing would not be subsidizing educational material but there would also only need to be server support instead of public room support. A rough estimate for this type of service would be a $2000/year equipment budget and 0.5 FTE distributed over the courses providing educational materials ((2000+(15 * 1920 * 0.5))/28 = $586 per course). There would be an additional cost for access. This would be approximately $17/student/course if students needed to purchase their own access through a commercial service. The cost would probably be less if provided by the College.

The next step in validating this data is to find out what actual usage is. The WWW server keeps a log of accesses which will allow us to determine how many times the program gets used and if students are going through the entire programmed text. Since these logs are based on machine access and our machines are in public areas, we will need to add a mechanism to determine which students are using the program. We will do this by adding a HTML form which will allow the student to enter their name and comments about the program. This data will then automatically be e-mailed to CBE. We will compare this data with questions included on the course evaluation given to every student at the end of the Respiratory Pathophysiology Course. The course evaluation will attempt to corroborate the student perceptions of the computer program as well as determine to what extent the paper materials are being used.

CONCLUSION

Deciding whether electronic material is cost-effective is largely dependent on institutional goals. If an institution is already committed to making productivity tools (such as word processing and statistics programs) available, then the infrastructure will be in place to provide low cost distribution of materials. Equally important is whether materials distributed are used by the students. This will be examined in a follow-up study.

References

1. Berners-Lee T, Calliau R, Luotonen A, Nielsen HF, Secret A. The World-Wide Web. ACM 1994;37:76-82.
2. Metcalfe ES, Frisse ME, Hassan SW, Schnase JL. Academic networks: mosaic and world wide web. Academic Medicine 1994;69(4):270-3.
3. D'Alessandro MP, Lacey DL, Galvin JR, Erkonen WE, Santer DM. The networked multimedia textbook: distributing radiology multimedia information across the Internet. AJR. American Journal of Roentgenology 1994;163(5):1233-7.
4. Kahn RM, Molholt P, Zucker J. CPMCnet: an integrated information and internet resource. Proceedings - the Annual Symposium on Computer Applications in Medical Care 1994;:98-102 .
5. Kruper JA, Lavenant MG, Maskay MH, Jones TM. Building Internet accessible medical education software using the World Wide Web. Proceedings - the Annual Symposium on Computer Applications in Medical Care 1994;:32-6, 1994.
6. Hutton JG, Jr., Levy RA, Martin HB. An alternative approach to teaching statistics to dental students. Journal of Dental Education 1982;46(3):147-52.
7. Veith S, Price M, Franck P. Teaching nursing management by programmed instruction. Journal of Nursing Education 1975;14(2):25-9.
8. Sidman RL, Sidman M. Neuroanatomy: A Programmed Text. Boston: Little, Brown, 1965. vol 1).
9. Mumenthaler M, Noack H. Programmed texts: success or failure? An analysis of medical students' opinions. Clinical Neurology & Neurosurgery 1977;80(4):241-50.
10. Thompson EC. Computer-assisted instruction in curricula of physical therapist assistants. Physical Therapy 1987;67(8):1237-9.
11. Reichel J, al. e. Programmed Texts Syllabus for Pulomnary Pathophysiology. Bronx, N.Y.: Albert Einstein College of Medicine, 1973.

Table 1. Measured Direct Costs

	Phase I	Phase II	Phase III
Transcription ($10/hour)	(41 hours) $410	$0	$0
Printing ($0.05/page)	(960 pages) $48	(200 pgs) $10	$0
Duplicating ($0.03/page)	$0	(200 copies) $1200	$0
Total	$458	$1210	$0

Measured direct costs for the conversion to word processor format and revision of the material (Phase I), production and distribution of the edited material on paper (Phase II), and the production and distribution of the edited material electronically (Phase III). Note that Phase III "measured" costs are zero because all costs for this phase were estimated.

Table 2. Estimated Direct Costs

	Phase I	Phase II	Phase III
Transcription† ($10/hr)†	(6 hours) $60	$0	$0
Content Editor ($150/hr)	(24 hours) $360	$0	$0
HTML Editor ($100/hr)	(19 hours) $1900	$0	(9 hours) $900
Total	$2320	$0	$900

Estimated direct costs for the conversion to word processor format and revision of the material (Phase I), production and distribution of the edited material on paper (Phase II), and the production and distribution of the edited material electronically (Phase III). Note that Phase II "estimated" costs are zero because all costs for this phase were measured directly. †Transcription of subsequent content edits on paper to electronic form were done by HTML expert.

Table 3. Estimated Indirect Costs

	Office of Instructional Support	Office of Computer Based Education
Total Effort (1FTE = 1920 hours)	3.5 FTE = 6720 hours	2.5 FTE = 4800 hours
Average Base Salary	$15/hour	$25/hour
Other Costs	Not Applicable	$80,000
Proportion of Total Effort for Distributing Educational Material (Proportion for other purposes)	50% (30% Exam Administration 20% Room Administration)	%20 (50% Word Processing 20% Electronic Mail 10% Statistics & Presentation)
Calculation of indirect cost for one of 28 courses	((6720 X 15) X 50%)/ 28	(((4800 X 20) + 80,000) X 20%)/28
Total	$1800	$1430

Estimated indirect costs for the conversion to word processor format and revision of the material (Phase I), production and distribution of the edited material on paper (Phase II), and the production and distribution of the edited material electronically (Phase III).