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ABSTRACT

An instructional development project at the University of Kansas focused upon two major objectives: (1) to develop teaching strategies to introduce engineering students and faculty to literature searching on computerized data bases, and (2) to help students develop effective on-line search strategies. A faculty workshop and an undergraduate engineering course designed to teach students methods of retrieving relevant literature were used for reaching the objectives. Attitude questionnaires and performance evaluations indicated that student attitudes toward on-line computer search methods, as well as quantity of relevant literature found, improved with the instruction and subsequent use of on-line search methods. (CMV)

Improving the Use of Computer-Based Information Resources Within the Engineering Classroom

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Computer science has made rapid progress since its technological inception in the 1940's. Improvements in the reliability of components, more rapid internal operating speeds, and enormous amounts of accessible memory have all contributed to present-day capabilities which would have staggered imaginations only 30 years ago. One result of this progress has been expanded computer service to the engineering community, in both educational and applied environments. Problem-solving, simulation studies, computer-based education and computerized information bases are generally representative of the services which have become increasingly important to engineers in recent years.

The increasing importance of computer applications in scientific and technological fields has gained national prominence. The Division of Science Information (DSI) of the National Science Foundation is currently sponsoring a number of projects with two basic goals:

1) The development of innovative tools to improve awareness by scientists, engineers and other users of the availability of science and technical information resources.
2) The improvement of currently existing instructional materials for teaching effective use of information systems, by developing computer-assisted instructional aids.

All of the sponsored projects are predicated upon the imperative need to base engineering and scientific work on a knowledge of the most relevant and current state-of-the-art information. In educational settings, the need for increased awareness of scientific and technical information resources centers on two problems; an increase in the amount of available information, which approximates an exponential curve in many fields, and the concomitant inability of libraries to provide extensive collections of books, journals or documents. It is conceivable, and indeed probable, that the future growth of information bases will force many engineering educators and professionals to rely largely upon computerized techniques to retrieve the bibliographic sources they need. At the same time, there will be a need for educational programs at the undergraduate and graduate levels which will provide training in the use of information resources. In a practical sense, two incidents examplify the need for more effective use of technical information. First, the failure of the type of suspension bridges built at Tacoma Narrows, Washington was predicted years before they were constructed. Secondly, fire hazards in certain types of 480 volt electrical equipment were documented in 1960, though the design of some equipment in 1968 failed to consider this problem publicly until 1971.

Three of the projects sponsored by DSI/NSF directly effect engineering education. The project at the University of California at Santa Barbara is directed toward developing teaching materials, courses, and course sequences which will integrate the use of information resources into undergraduate science and engineering curricula. Another project at the New York Institute of Technology, Westburg, New York, is aimed at developing study and training materials for improving the knowledge of and access to technical information by engineering students and faculty. The third project, and the subject of this paper, is being conducted at the University of Kansas and focuses upon the development of teaching materials to introduce engineering students and faculty to computer-assisted literature searching, while stimulating more effective manual search methods. An additional component of this project is a follow-up study to determine the extent to which graduates employ these skills after graduation.

The purposes of this project were; 1) to develop appropriate instructional delivery systems, including materials and procedures, 2) to schedule and complete instructional sessions in undergraduate and graduate engineering classes, and 3) to assess the short- and long-term effects of instructional intervention. The activities which took place in these areas, during the first year of the project, will be described in the following sections of this paper.

Development of Instructional Materials

During the summer of 1976, prior to instructional intervention, the science librarian associated with the project compiled information packets which focused on tools for searching the literature of electrical, chemical and petroleum, and aerospace engineering. These packets focused on the use of indexing materials in each field, and included a glossary of library and information science terms useful in literature searching. The packets were used as the primary instructional materials during the first year of the project (1976-77), though they have since been revised into a more general document entitled "Tools for Searching the Technical Literature". As a supplement to the information documents, a handout on search commands, codes, and data bases was prepared by two engineering graduate assistants. This handout was aimed at acquanting students with the steps necessary to prepare an on-line search using the Lockheed DIALOG* system, the computerized information base employed by the project.

The engineering faculty associated with the project collaborated on the development of a series of 35mm color slides which document and describe the information explosion and approaches to dealing with it. Slides were developed in sections which addressed; 1) The problem of information transfer and access, 2) the use of the Engineering Index and other conventional and computerized literature search methods in dealing with these problems, and 3) search strategies and sample searches associated with the use of DIALOG. The slides were originally used with the faculty workshop presentation during Fall 1976, and subsequently revised for use in engineering classes in Spring 1977. Bibliographies of thesauri, abstracts, indexes, and journal guides were also prepared, one for each engineering area dealt with, to assist with the instructional sequences dealing with manual searching.

Instructional Procedures

At the inception of the project, instructional interventions were planned to achieve two main objectives:

1) to communicate what on-line searching is and why it

* Trademark Reg. U.S. Pat & Trademark Office.

is useful in the process of locating and acquiring needed information;

2) to help students develop effective on-line search strategies.

As the project developed in the first year, the second objective was de-emphasized due to the substantial time and effort required for students to become proficient terminal operators in on-line searching. In addition, it became apparent that the use of a trained intermediary to execute searches was both convenient and cost-effective.

The classroom presentations dealing with on-line searching employed the instructional materials developed, and took place in 1 graduate and 6 undergraduate engineering classes during the 1976-77 academic year. Each session was accompanied by a discussion period where students were able to ask questions. Following these presentations, students (in small groups) were asked to prepare a formal search strategy and make an appointment for having the search executed. Students were also expected to be present during the actual search and to make any needed revisions in their strategies, based on the results they obtained. This latter component of instruction, best described as experiential learning, was most successful with classes which had a scheduled lab period longer than 1-hour.

The in-class presentations on manual literature searching were aimed at providing students with knowledge of points of access to the technical literature, as well as document retrieval processes. Students were exposed to simulated searches, beginning with the recognition of need for specific technical literature and culminating with the steps needed to obtain it. In identifying literature sources, emphasis was placed on the efficient use of indexes and thesauri. Document retrieval training focused on acquainting students with the university libraries system and the use of inter-library loan in obtaining documents not owned by the university.

A faculty workshop in computer-aided preparation of bibliographies was announced to School of Engineering faculty during the Fall 1976 semester. The workshop was conducted in two sessions; the first session included presentations similar to those made in engineering classes and the demonstration of an on-line search by the trained intermediary. Faculty members were then invited to prepare a search strategy on a topic of interest to them, for use at the next session which consisted of excuting searches based on the strategies developed. The second session involved each faculty member working with the intermediary for about an hour of on-line searching.

Instructional Variation

It is necessary, at this point, to describe some differences which arose during instructional intervention. Although all participating classes received identical presentations and the benefit of discussion periods, the same consistency did not obtain in the experiential component of instruction. This was largely due to the fluctuations of students' personal schedules and the topics assigned or suggested by the instructors in engineering classes. These differences become important in the evaluation of instructional results, in as much as it must be remembered that the observed results of training are the "average" results of some-what different instructional procedures and, therefore, do not represent the optimal condition where all participants would consistently receive both training and hands-on experience in a closely controlled setting. It should thus be kept in mind that the findings of the project would likely increase the situation where ideal conditions could be implemented.

Evaluation Results

To summarize the aims of the project in its early phases, two main objectives were developed as follow:

1) Engineering faculty and students participating in the project will become persuaded that automated literature searching is an effective tool in support of their work and will utilize it if it is available to them.

2) The quality and quantity of the information collected by engineering students in the preparation of design and research projects will be improved by the use of automated literature searching.

The degree to which the first objective was met was assessed by analyzing the results of several questionnaires completed by faculty and students in participating classes and the faculty workshop. The second objective was tested through the interpretation of log data which students gathered during automated and manual searches.

Students who participated in Fall 1976 classes completed a brief questionnaire which asked them to subjectively rate important instructional outcomes (see Table 1). Several conclusions were determined by statistical tests of the obtained results:

1) Students saw on-line searching as more efficient than manual in terms of time spent.
2) Students saw on-line searching as more efficient than manual in terms of relevant articles found.
3) Students saw on-line training as more useful than manual search training.

Insert Table 1 about here

From these results, it may be concluded that students found on-line searching to be an effective tool in support of their work, thus confirming that one objective of the project had been met. It is interesting to note that a majority of students preferred a combination of on-line and manual search techniques as opposed to either method by itself.

A more extensive questionnaire (the Literature Search Evaluation, of LSE) was given to students in participating classes during the Spring-1977 semester. In addition, students in several engineering classes which received no training completed the questionnaire and served as a comparison (control) group in the evaluation of results. The differences in response between training and control students may be seen, in detail, in Table 2. The analysis of these differences showed that control students who rated on-line searching unfavorably at the beginning of the semester tended to move toward neutral ratings at the end of the semester, while students in classes moved from pre-semester neutrality to post semester favorability. In addition, training students exhibited significantly greater confidence than controls in their on-line and manual search skills at the end of the semester. It may be concluded that the students who received training in the Spring semester, like those in the Fall semester, found on-line searching and general searching training to be an effective tool in support of their work.

Insert Table 2 about here

The data used to determine whether the second objective (improved quality and quantity of information collected) was met is presented in Table 3. Relevant citations were tallied as those which students rated as "good" or "excellent". In comparing the on-line and manual search results on the same topic, it was found that students spent significantly less time formulating and conducting on-line searches and that the cost per relevant citation was lower for on-line searches. The results from classes which conducted only an on-line search tended to confirm these trends. The overall cost per relevant citation remained within a small range ($1-6) for on-line searches, with overall averages of $3.76 (industrial estimate) and $2.73 (educational estimate). Depending upon the size of the data base searched, these estimates would seem to constitute nominal costs per citation. It may thus be concluded, for both undergraduate and graduate students, that on-line searching was effective in improving the quality and quantity of citations produced; it was also cost-effective for both industrial and educational settings.

Insert Table 3 about here

The Fall-1976 faculty workshop participants included 8 faculty members from civil, chemical and petroleum and aeronautical departments, as well as 2 members of the library staff. The majority of participants indicated at the beginning of the first session that they were basically unfamiliar with on-line search methods and results. Participants rated each session, at its completion, in three important areas; the results may be seen in Table 4. An overall rating was also obtained subsequent to the second session, with the results shown in Table 5. The purpose of the faculty workshop was to provide a general understanding of on-line search techniques and their potential. Since trained intermediaries are capable of providing the technical skills necessary for on-line searches, the intent of the workshop was to provide a conceptual understanding and promote attitudes reflective of acceptance of the technique and trust in the results. The evaluative assessments reveal that this purpose was satisfactorily accomplished.

Insert Tables 4 & 5 about here

Summary

The statistical analysis of training and search results indicated that the project had satisfactorily met the objectives of promoting more positive attitudes toward on-line searching and improving the quality and quantity of citations yielded by this type of search. Student attitudes toward literature searching in general were also improved by the instructional treatment. In addition to these objective findings, the anecdotal comments of participating instructors were pooled and resulted in the following conclusions:

1) Instruction in literature searching enables engineering students to locate and retrieve library materials with greater efficiency and precision than was previously the case.

2) Literature search activities performed by the student must be meaningfully related to the technical subject matter of the course, rather than perceived as "busy work".

3) The use of trained searchers as intermediaries between the engineer and on-line retrieval services will be cost effective for both university and applied environments.

4) Successful use of the instructional procedures and developed materials depends upon a genuine information need within the framework of the course in which instruction takes place. To ensure this need and the students' ability to meet it, the specific topic must be carefully chosen and the literature checked in advance, at least in the early search efforts.

It should be kept in mind that the positive results obtained in this project are tied to a relatively brief instructional and practice sequence. There is good reason to believe that even more positive effects would obtain in situations where a larger proportion of course time, or a one-credit short course, could be devoted to search training.

The present project encompasses two objectives which were not mentioned previously as they are presently untested. The first of these is a study to determine to what extent engineering graduates who received training maintain a positive attitude toward on-line searching and a tendency to use it when appropriate and when prevailing conditions permit such use. This objective is currently being assessed by a follow-up study which asks engineers who received training as students to report the degree to which they encounter literature needs that require a search and the availability of on-line searching in their current professional positions.

The questionnaire will be accompanied by an offer to provide on-line searches at cost to engineers who do not have local access to the tool. The second objective is to assess the need for and availabilty of on-line searching to engineers who did not receive formal training as students. This step will yield comparative information for contrasts with engineers who were trained and will serve to acquaint a larger group of engineers with the potential of on-line searching and the at-cost availabilty of the technique if they should need it or wish to become familiar with the method.

The educational and practical demands of the rapid growth of engineering information bases have been, and will continue to be, amply illustrated. The overall goal of the present project is to enhance the quality of engineering education by developing an instructional sequence and materials which may be used in existing courses to acquaint students with more effective techniques of literature searching. It may be concluded that this goal has thus far been met and, in conjunction with the results of related projects supported by NSF, it is likely that the on-going effects of literature-search training will make themselves felt as a higher degree of quality in engineering practice.

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Table 1

Student Responses to Items Concerning Manual and On-Line Literature Searches (MLS/OLS) during Fall, 1976

Item	Search Type	Students: Grad YES	Grad NO	Undergrad YES	Undergrad NO
1. Conducted an MLS?	MLS	5	0	22	1
2. MLS efficient in time spent?		1	4	9	14 *
3. MLS efficient for # of articles?		4	1	13	10 *
1. Conducted an ALS?	OLS	5	0	21	1
2. ALS efficient in time spent?		5	0	21	1 *
3. ALS efficient for # of articles?		5	0	20	2 *

Student Ratings and Preference for OLS and MLS

Item	Search Type	Grad MEAN	Grad SD	Undergrad MEAN	Undergrad SD
1. Usefulness of library training?	MLS	1.8	1.3	3.65	1.3 **
2. Usefulness of MLS training?		1.6	1.3	3.56	1.5 **
3. Usefulness of MLS materials?		2.2	1.6	3.43	1.3
4. Accuracy of results - MLS over ALS[1]?		4.2	1.3	3.62	1.6
1. Usefulness of ALS training?	OLS	1.2	.45	2.4	1.6 ***
2. Usefulness of ALS materials?		2.6	1.3	2.7	1.3
Preference for MLS, ALS, or a combination[2]?	Both	MLS ALS COMB 0 1 4		MLS ALS COMB 1 7 13	

Note: All items, except as noted, are scored on a Likert scale from 1 (very useful) to 6 (no value).

1. Scored on a Likert scale from 1 (much more accurate) through 4 (equal) to 7 (much less accurate).

2. Data are reported as frequencies.

* significant difference ($p<.01$) between ALS and MLS, using McNemar's test.

** significant difference ($p<.05$) between classes.

*** significant difference ($p<.05$) between OLS and MLS and between classes

Table 2

Treatment vs. Control Post-Test Differences

by Items on the Literature Search Evaluation (LSE) Scale

Level of Signif.	Item	Gp.	$\bar{X}$	Median	SD	Item Statement
*	1	TR	1.46	1.39	.55	literature search skills necessary for
		CO	1.69	1.75	.55	engineers (TR = + agree)
+	2	TR	2.05	1.97	.82	have sufficient knowledge for conducting
		CO	2.80	2.62	1.07	manual search for design problem (TR= +agree)
NS	3	TR	2.45	2.31	.95	sufficient skill for manual search (no
		CO	2.93	2.75	1.10	difference)
+	4	TR	2.56	2.35	.98	adequate instruction in manual search
		CO	3.36	3.29	1.09	(TR = + agree)
*	5	TR	3.69	3.74	.92	manual preferred over auto (CO = + agree)
		CO	3.27	3.17	.84	
+	6	TR	2.79	2.64	1.00	adequate instruction in auto (TR = + agree)
		CO	3.80	3.87	1.03	
+	7	TR	3.26	3.44	1.00	as engineering student-acquired sufficient
		CO	3.97	4.10	.97	skill in auto (TR = + agree)
+	8	TR	3.12	3.10	1.04	sufficient skill for auto search on design
		CO	3.93	4.05	.97	problem (TR = + agree)
+	9	TR	2.56	2.31	.98	I understand how to develop auto search
		CO	3.99	4.10	.94	(TR = + agree)
+	10	TR	2.69	2.63	.96	satisfaction with overall results of auto
		CO	3.19	3.08	.77	(TR = + agree)
+	11	TR	3.01	3.07	1.04	auto more expensive than manual (CO= + agree)
		CO	2.81	2.88	.69	
+	12	TR	3.91	4.04	1.05	manual over auto for time and effort
		CO	3.24	3.14	.79	(CO = + agree)
+	13	TR	3.60	3.78	1.02	manual over auto for relevant items produced
		CO	3.03	3.02	.66	(CO = + agree)
+	14	TR	2.55	2.45	.91	auto summaries more comprehensive than
		CO	2.83	2.91	.53	manual (TR = + agree)
+	15	TR	3.69	3.76	.85	equipment needs make auto impractical
		CO	3.31	3.19	.64	(CO = + agree)

Table 2 (cont'd.)

Level of Signif.	Item	Gp.	$\bar{X}$	Median	SD	Item Statement
+	16	TR	2.47	2.47	.70	auto options satisfactory (TR = + agree)
		CO	2.87	2.93	.41	
+	17	TR	3.57	3.72	.91	manual preferred because individual is in control (CO = + agree)
		CO	3.04	3.03	.70	
+	18	TR	4.56	4.66	.60	literature search of little value in engineering (CO = + agree)
		CO	3.88	3.99	.93	
*	19	TR	3.22	3.18	.98	satisfied with auto service accessibility (TR = + agree)
		CO	3.38	3.22	.75	
+	20	TR	2.87	2.81	.86	satisfied with thesauri, etc. accessibility (TR = + agree)
		CO	3.19	3.10	.82	
NS	21	TR	1.97	1.94	.77	auto service and training should be provided to engineering students (both agree)
		CO	2.05	2.05	.72	
NS	22	TR	2.72	2.59	.99	most needs met through manual search (both agree)
		CO	2.70	2.70	.77	

Significance levels: * = .05, + = .01

Table 3
Cost/Relevance Estimates for 1976-77

Item	Search Type	Classes										Average by classes
		Fall-76			Spring-77							
		EE490		CPE801[1]	EE641				CPE699[1]		AE522[1]	
time (hrs.)	MLS	3.24	1.5	80	2.15	.72	-	-	-	-	-	7.11
total citations	MLS	5.28	4.8	15	9.26	4.25	-	-	-	-	-	9.97
relevant citations	MLS	4.38	4.2	15	8.65	4.24	-	-	-	-	-	9.96
cit.'s redundant to ALS	MLS	1.14	.99	-	1.83	1.59	-	-	-	-	-	1.49
cost per rel. cit. on a per-student basis		$12.55	$13.08	$53.33	$3.46	$3.00	-	-		-	-	$23.11
time (preparation)	OLS	1.86	1.1	-	.87	.5	1.02	.6	-	-	-	1.25
time (on-line)	OLS	.34	.16	1.65	.37	.15	.35	.13	1.19	.80	.89	.80
total cit.'s	OLS	46.3	23.5	105	28.1	9.9	25.2	15.5	176	141	22	77.7
rel. cit.'s	OLS	20.5	9.5	48	14.9	5.5	10.1	7.2	42	140	17	41.8
cost I *	a	$33.51	$14.43	$186.14	$24.98	$9.82	$24.24	$8.83	$105.77	$94.65	$60.88	$75.74
cost II **	a	$27.64	$11.65	$26.40	$32.24	$13.21	$35.62	$13.07	$30.94	$20.80	$23.14	$28.11
cost per rel. cit.	a	$3.45	$2.01	$4.43	$3.48	$2.84	$5.92	$3.67	$3.26	$.82	$4.94	$3.76
cost I	b	$33.51	$14.43	$186.14	$24.98	$9.82	$24.24	$8.83	$105.77	$94.65	$60.88	$75.74
cost II	b	$13.34	$6.10	$9.90	$4.05	$2.01	$8.22	$4.16	$7.14	$4.80	$5.34	$7.54
cost per rel. cit.	b	$2.88	$1.59	$4.08	$2.35	$2.21	$3.11	$1.76	$2.69	$.71	$3.90	$2.73

a - Industrial cost estimates; user time = $10/hr., intermediary time = $16/hr. Manual searches include user time only.
b - Educational cost estimates; intermediary time = $6/hr., user time = 0
* - includes on-line, print-out, and telecommunication costs.
** - includes user and intermediary time costs.
1 - search was conducted as a group - no individual searches

Table 4

Ratings of 1976 Faculty Workshops

Session I (November 30)

Item	Scale Interpretation	MEAN	SD
New information acquired	1 = Considerable 6 = None	1.67	1.12
Utility to faculty or professional needs	1 = Very Useful	1.44	.73
Overall rating of session	1 = Excellent 5 = Poor	1.67	.71
Session II (December 2)			
New information acquired	1 = Considerable 6 = None	1.43	.79
Utility to faculty or professional needs	1 = Very Useful 6 = Of No Value	1.86	.90
Overall rating of session	1 = Excellent 5 = Poor	1.57	.79

Table 5

Overall Ratings of 1976 Faculty Workshops

Item	Scale Interpretation	MEAN*	SD
Utility of information acquired	1 = Very Useful 6 = Of No Value	1.29	.76
Utility of information for AIS		1.43	.79
Utility for adaptation to your courses		2.2	.84
Utility for sharing with your graduate students		1.43	.79
Utility of AIS for the practicing engineer		1.14	.38

* Two participants did not respond to these items.