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THE PERCEIVED USEFULNESS OF COMPUTER INFORMATION SOURCES: A FIELD STUDY

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ABSTRACT

A joint IBM-SHARE' field study surveyed 229 computer users about their use of a range of information sources. On a questionnaire, each respondent described a situation where information was required to use a computer. The respondent then specified all the information sources that were consulted, judged the degree to which each met the information needs, and estimated the time required to obtain the information. -With a keyword technique, responses were coded to identify user cognitive states from the situation descriptions. Three unique cognitive states identified: Learning, Solving, and Refreshing.

For learning and problem solving, the best online and human sources are used at about the same rate, 70% of the time; but, humans are rated more effective at 80% versus 60% for online sources. When effective, human sources require more time, on average 24 minutes versus 9 minutes for online sources. The conclusion drawn from the study is that human sources are rated more effective than online sources because humans have four critical advantages. They are *interactive* speakers and listeners. They can be selective in the information presented. Humans can query at multiple levels of discourse. Humans can *assess* the relevance of the information presented.

INTRODUCTION

A joint IBM-SHARE field study surveyed computer users about their use of a range of information sources. The survey addressed the question of what information sources are used and whether they are found effective to meet the users' information needs. The data were collected under the sponsorship of the SHARE Human Factors Project in cooperation with the SHARE Documentation and Standards Project and were reduced and analyzed by IBM.

Background

Much attention has been focussed over the years on what types of information should be provided to computer users. Concurrent with this focus, there has been much attention paid to the delivery systems for these types of information (for example, hard copy documentation). One major emphasis has been on developing online information with the goal of providing provide users with almost all of the information required for learning and using the computer through the computer itself. To date, the success of these endeavors has been mixed, both with respect to content and delivery.

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[1] SHARE **Inc. is an independent computer users group whose members include many** Fortune 500 companies and major universities that use large IBM **systems.**

The opinions expressed here are those of the authors, and do not necessarily reflect those of the IBM Corporation, SHARE, Stanford Linear Accelerator **Center, or the U.S. Department of Energy.**

One step towards improving information facilities is to determine what information sources computer users employ. By exarnining what types of assistance users now seek, along with the degree of success achieved, design factors for improving information assistance can be isolated and identified. The study reported here examined the use and utility of *a diverse spectrum of assistance sources* available to computer users.

Because users continually solve problems and improve their computer skills through whatever means available, the process of *selecting* sources of information for a specific problem provides significant insight for the design of online information facilities. Thisinsight can be especially valuable if it sheds light on the critical factors in selecting *successful* sources of information, that is, those that provide a relatively quick and effective resolution of the problem.

Most people find solutions to a wide range of everyday problems by choosing among available information resources. Through experience, choices made later reflect the trial-and-error learning acquired about sources chosen earlier. One should expect that computer users learn which assistance sources to seek for specific computer problems based on an internally developed, subjective probabilities of obtaining the correct information.

The availability of multiple help sources has typically not been determined on the basis of any valid, predetermined criteria that are anchored in the learning state of computer users; instead, help sources have been designed on the basis of the efficiency and economy of the delivery system. As a result, when user experience is low, the tactic of providing all potential information without some selection criterion works against users selecting the correct information source(s). Systematic research in this area is just beginning to emerge.

Much of the previous work on help facilities has been developmental as opposed to research in nature. For reviews of the developmental work we suggest papers by Sondheimer and Relles [12] and Houghton [10] who have catalogued assistance and help facilities, along with their features. Sondhcimer and Relles review major development efforts in the area of online help, and provide an excellent description of differences among the facilities, for example, help access methods and the data structures employed by help facilities. Houghton's taxonomy shows that online help ranges from low-level message assistance to sophisticated tutors that attempt to be sensitive to users' situations. Despite the diversity of design that can be observed in help facilities, only a small number of empirical studies have investigated help facilities and their effects on computer users. Factors that have been investigated include whether help is hard copy or online, the level of specificity of information provided in help, and the level of the user's task goals when help is requested.

Magers [11] compared a standard help facility with one modified purposefully to enhance its usability and usefulness. Modifications included adding a key to initiate help in addition to the help command, rewording messages so they suggested corrections in addition to merely pointing out errors, and adding a tutorial, feature to help. Thirty computer novices were randomly assigned to two groups of 15 and worked on a typical series of tasks in office data processing. The group receiving the modified help outperformed the group with the standard help on all measures. To illustrate, 14 of the 15 in the modified help group completed the experimental tasks; only 3 of the 15 in the standard help group were able to complete the task. Mager's study clearly indicates that the learnability and usability of computer systems can be significantly improved through specific application of selected human factors and psychological principles.

Gilfoil [8] studied 4 computer users intensively across a months time as they learned to use a personal computer to perform typical data processing tasks. Referrals to a general level of help (for example, a list of data-base commands) and a specific level of help (for example, syntax of the change command) were counted across 20 learning sessions, each of which occurred on a different day. Initially, the learners made many referrals to help, which were predominantly to a general level. Referrals to help steadily declined through the first five sessions. Then, as the subject switched from a menu-mode to a command-mode of dialogue (at about the fifth day of learning), their references to help steadily increased, and were predominantly to the specific level of help. The increase continued through the 8th session; referrals to help steadily decreased, reaching an asymptotic low level after mastery of the command-mode around session 11. Gilfoil's results indicate that as the user's understanding of the interface grows and becomes more discriminating, and as the user assumes control of the interaction, the use of help becomes more selective and specific.

The experiment of Barnard, Hammond, MacLean, and Morton [3] investigated three factors in learning a command language for text editing. The three factors included 1) specific versus general command names (called here the *names* factor), 2) whether the goals were set at a sub-goal level, requiring one command to attain, or a super-goal level, requiring six commands to attain (called here the goals factor), and 3) whether help just listed the commands (general help) or also provided a definition of function (specific help). Because any reference to the specific help required an initial reference to the general help, a direct comparison of the use of general versus specific help according to other experimental variables was not possible. The names factor affected the use of specific help; the group using general command names referred significantly more frequently to specific help across trials. The goals factor affected the effectiveness of general help; the sub-goal group entered a command as the next action after accessing general help significantly more often than the super-goal group. Since the only two options for leaving general help were to go to the specific help or enter a command, this finding indicates that the sub-goal group, which had higher task structure, successfully resolved their problem with just a listing of the command names, whereas solvers with the unstructured task more often required the specific help. In

general, the results of the Barnard et al. study indicate that the names factor determined the frequency of referring to help, with general, that is, more vague terms requiring more frequent help reference. The goals factor determined the effectiveness of a referral to general help; the sub-goal group, which had a highly structured task, found general help effective.

Cohill and Williges [6] examined the effects of three help factors on the text editing performance of naive users. A command based editor was used. The performance of 8 groups receiving help was compared with a control group receiving no help. The help factors investigated included 1) whether the user or computer initiated the help interaction, 2) whether the user or computer selected the specific sequence of information-displayed in a help interaction, and 3) whether the help information was presented online or through hard copy. In the conditions where the computer selected help information, it was constrained to one command for any given interaction and the command was selected from a set of four that constituted the basic commands. There were ten additional advanced commands, and those in groups where the computer did not select help could receive help on the advanced commands. A number of dependent measures were taken to assess text editing performance. The major findings were that any help condition produced better performance than the control (no help) condition, in that task completion required a shorter time, involved fewer errors, fewer numbers of commands, and showed more subtasks completed. Conditions where users initiated and selected the help interaction showed better performance than the other help conditions in time to task completion, errors, and number of commands. Finally, those in conditions where the user selected the help and it was on hard copy outperformed the other groups receiving help requiring shorter time to complete the tasks, making fewer errors on the task, and making fewer errors after requesting help. From the results of their study, Cohill and Williges concluded that naive computer users receive the best help if they both initiate the interaction and select the subject of the interaction. Furthermore, they suggest that help information be presented in hard copy form. To be complete, we add that the computer initiation and selection of help was both limited and rigid, in that help was available on only 4 commands.

Dunsmore [7] investigated the influence of three factors on using a computerized information retrieval system to answer questions: 1) A help factor of providing help in three different ways--a) as an introduction to the task only, b) as a complete description of the system commands and capabilities that were always available online, and c) the same complete description as in group b, but in written form and constant availability. 2) A dialogue factor, supporting either a-single entry at any given time or multiple entries, allowing a "fast path" through the retrieval system. 3) A format factor which included a horizontal format of putting as much information as possible on each line of the screen (with wrapping to the next line where required), versus a vertical format, where information was displayed in tables so all pieces of information about one entry were placed on one line of the screen. Only the help factor had a significant effect on the number of questions answered. The group receiving the online help answered significantly fewer questions than the other two groups. Dunsmore interpreted this finding as indicating that the online documentation was more distraction than help, and he cited anecdotal evidence to support the interpretation.

In the areas of computer advising and intelligent help, Carroll, McKendree, and Aaronson have collaborated on a number of studies [1, 2, 4, 5]. Their studies have taken the tack that successful online assistance facilities can be developed by duplicating the interaction with a human advisor in an intelligent advisory interface. Consequently, they have extensively studied user-advisor interaction in a number of modes. They have found that user assistance is a necessary component of current human-computer interaction. Their specific findings include that people have trouble learning computer systems, and that their skill tends to plateau at a relatively low level. With respect to advisor-user interaction, their research has found that users submit simpler requests when communicating with advisors over terminals than in a face-to-face meeting. Furthermore, remote advisors, who communicate through electronic mail, will provide multiple alternatives in a one-shot consulting session to ensure the correct answer is included. In sum, their findings point to the fact that people would rather spend their time *working* on the computer instead of *learning* to use the computer.

In summary, previous studies have shown user assistance to be a necessary component to use current computer systems. They have investigated the influence of many design factors on user behavior and performance in seeking information online and from human advisors. To date, little emphasis has been placed on user cognitive states, strategies employed by users in the field to obtain assistance for problems encountered online, or a field comparison of the use of alternative information sources of computer information. The current study attempts to deal with these issues.

Objectives

The objectives of the field study were threefold:

1. To determine empirically what information sources are used by computer users and which are found effective, with a central focus on online information sources.
2. To assess the effects of user factors on the selection and effectiveness of information sources.
3. To identify possible explanatory principles to account for users' selection of information sources.

METHOD

A survey method was employed that used a pencil-and-paper questionnaire.

Questionnaire

The SHARE Human Factors and Documentation and Standards Projects cooperated to develop a questionnaire for assessing the use and effectiveness of varieties of documentation and other sources of information. The questionnaire asked the computer user to..."recall a specific situation within the last month when you were working at a computer terminal and you needed information." After describing the situation, the respondent rated 12 information sources on the following 3 scales:

1. The ease of accessing the information source.
2. The understandability of the information.
3. The usefulness of the information.

Each rating scale had four points. For scaling the ease of access, the points were very difficult, difficult, easy, and very easy access. The other scales had similar points.

The 12 information sources included 9 online sources, 2 human sources, and 1 for printed documentation. They were:

- Online suggestion
  Online message detail
  Online option list
  Online command help
  Online help for subject
  Online example
  Online tutorial
  Online index
  Online document
  Printed document
  Another user
  Consultant/supervisor

After rating each information source, the respondent estimated the time required to find the information. The questionnaire also covered demographics including current position, experience with computers, and experience with the currently used operating system.

Questionnaire Distribution

Members of the SHARE Human Factors Project coordinated the production and distribution of the questionnaires. They were distributed to local coordinators at about 20 SHARE member installations across the U.S. The local coordinators enlisted volunteer users, who filled out the questionnaires. The local coordinator returned them to the committee chair, who had them keypunched and sent them to IBM for data analysis. Respondent anonymity was preserved throughout the process.

Data Coding and Analysis

The IBM Representative to the SHARE Human Factors Project directed the coding and analysis of the data. The situations described by the users were coded using two methods of categorization. One categorized the situation by the problem area, for example, FORTRAN programming or sending mail. The other involved searching for keywords, which were commonly used throughout the situation descriptions. The data were analyzed using descriptive, bivariate, and correlative techniques.

RESULTS

The major results of the study are summarized in this section, starting with an analysis of the consistency of the responses for the purpose of assessing validity. For the compete analyses, see Granda and Halstead-Nussloch [9], and Winters and Sours [14].

Consistency of Questionnaire Scales

The number of usable questionnaires was 229. To assess the consistency among the three scales, two analyses were performed:

Concordance — The percent concordance for an information source is the percent of the respondents who indicated use or non-use of the source on **all three scales.**

Correlation — The correlation between the respondents ratings on two scales.

Concordance Results

The range of percent concordance of the three scales across the twelve information sources was 79% to 9 1%. The median concordance percentage was 87 % .

Correlation Results

Correlations between ratings on the access and understanding scales ranged from 0.75 to 0.93 across the 12 information sources. The access-usefulness correlations ranged from 0.75 to 0.91; the understanding-usefulness range was 0.80 to 0.92.

Usefulness chosen as base scale

To simplify the presentation, the analyses presented here are based on the usefulness scale, which is representative of the results obtained on all three scales. The large concordance percentages and inter-scale correlation values indicate a sufficient degree of consistency among the three scales to choose a single, representative scale. The results of the data analyses on usefulness are presented in three major catcgorics:

- Computing Environment and Demographics
- Use and Effectiveness of the 12 Information Sources.
- Cognitive State

Results--Computing Environment and Demographics

The questionnaire asked about the business activities, computing and job environment, and demographics. The following results were obtained.

Business Activities

A wide variety of business activities were represented in the survey sample. Education and manufacturing were respectively first and second with 81 and 50 respondents.

Job Environment and Computer System

Programming was the predominant job, with 73 respondents. Education and research were second with 33 each. ISPF was the predominant system, with 65 respondents. CMS had 47 and TSO had 36 respondents. Systems other than CMS and TSO were used by 77 respondents.

Experience Levels

Almost all the- respondents had extensive experience using computers. The median time was 6.8 years, with a modal value of 10 or more years of using computers. The majority of the respondents had more than six years of experience using computers.

In contrast, respondents had much lower levels of experience with the specific operating system. The results fell in a symmetric distribution with a mean, median and mode of about 18 months. The majority of the respondents had less than two years of experience using their current operating system.

Results--Use and Effectiveness of the 12 Information Sources.

Table 1 shows three percentage figures; the first two are percentages of the total number of respondents:

1. The percentage who used the information source.
2. The percentage who used the information source and also rated it as useful or very useful, that is, found it effective.

The third column is the percentage of information-source users who rated it as effective. The information sources are ordered by the the percentage who found it effective. Human sources hold ranks 1 and 2; printed documentation holds number 3. The online sources hold ranks 4 through 12. Similar results were obtained for the ratings of ease of information access and understandability.

Results - Cognitive State

Through reading the problem descriptions, three keywords (or their equivalent paraphrases) were present in almost every situation description:

1. I was **learning** how to do X . . .
2. I was **solving** the problem of making Y work . . .
3. I was **refreshing** my memory on the Z facility . . .

Upon discovering that the three consistently occurred, we decided to place the situation descriptions into the three categories: learning, solving, and refreshing. The three keywords, or their paraphrases, were used to make the categorization. Of the 229 questionnaires, 224 situation descriptions could be categorized; 51 were coded in the learning category, 114 in solving, and 59 in the refresh category--respectively, 23%, 51%, and 26%.

Table 1. Ranking of the Use and Effectiveness of 12 Information Sources

Source	Percent who Used	Percent Who Found Effective	Percent Users Who Found Effective
Another User	63	54	85
Consultant or Supervisor	54	45	83
Printed Documentation	58	44	76
Online Help for Command	61	41	67
Online Document	51	37	73
Online Suggestion	51	25	48
Online Index	41	25	61
Online Tutorial	41	25	62
Online Message--Detailed	44	17	39
Online Help on Subject	31	15	47
Online Option List	35	13	37
Online Example	28	12	42

Cognitive State and Finding Information

The cognitive state of a user has effects on finding information. The median time to find information is significantly longer for learners (17 minutes) and solvers (25 minutes) than for refreshers (4 minutes). The chi-square is 35.03, and with df = 10 shows significance of $p < 0.00$ 1. The median number of information sources tried is 6 for learners, 4 for solvers, and 4 for refreshers; the chi-square (1.795, df = 2, $p > 0.3$) is not significant. Learners try more information sources and require a longer time to find the information than do rcfreshcrs. Solvers take longer than refreshers, but consult the same number of sources.

Cognitive State and Experience Level

Cognitive state is statistically related to the amount of experience with the specific operating system (chi-square = 31.11, df = 8, $p < 0.001$). Forty-one percent of the learners have 6 or fewer months of experience with the operating system, while respectively 20% and 12% of the solvers and refreshers have that level of experience. In contrast, cognitive state shows no statistical relationship to the level of experience with computers (&i-square = 1.48, df = 6, p = 0.96).

Figure 1 shows the percent of respondents in the learning state as a function of the length of time on

computers and the length of time with the current operating system. Regardless of the amount of cumulative experience with computers, users who are inexperienced with the operating system or application are more likely to be learning than solving or refreshing.

Cognitive State and Effectiveness

Cognitive state had a number of significant effects on the effectiveness ratings of the information sources. Table 2 contains three analyses performed on the usefulness scale. The first covers the effectiveness of online help for a command. Chi-square[2] was used to analyze the (3 by 2) tables of cognitive state versus effective/not effective. Significantly more refreshers rated online help for a command as effective than did learners or solvers. Refreshers and learners find printed documentation significantly more effective than do solvers. A consultant or manager appears equally effective for all three cognitive states. As indicated by the ratings, cognitive state appears to be a determining factor in the effectiveness of non-human information sources.

Table 2. The Effects of Cognitive State on Three Information Sources

Cognitive State	Online Help Percent Effective	Printed Documentation Percent Effective	Consultant/ Manager Percent Effective
Learn	66	84	75
Solve	57	64	83
Refresh	89	92	94
chi-square	8.4	8.8	2.5

Information Sources for Learning

An important question is how users employ information sources to learn and solve problems on the system: for these two situations, Table 3 compares the most frequently used of the human sources (another user), the most frequently used of the online sources (online help for a command), and printed documentation. It shows the median number of minutes required to find the information to solve the problem, the percentage of users who said they used the information source, and the percentage of those who used the information source who rated it as effective. The human source is rated as most effective; According to a confidence-belt test for proportions, the effectiveness of the human source was greater than that of the online source with a p = 0.1 degree of significance. The human source also requires more time on average than the other two sources; this difference is marginally significant at the 0.05 level (chi-square = 5.54, df = 2, p = 0.06). The effectiveness of printed documentation falls between the human and online sources, but time requirements match those of online sources.

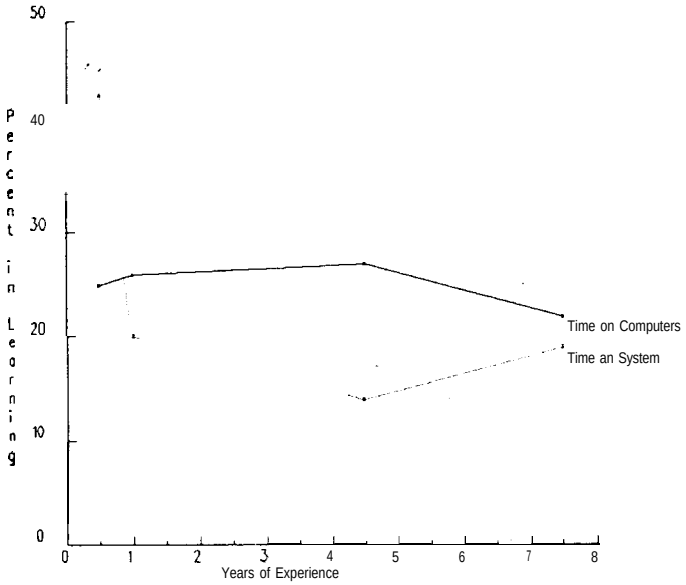

Figure 1. Experience Level and Percent in Learning State

Table 3. Comparison of the Best Human, Online, and Printed Information Sources in the Learning and Problem Solving Situations

Source	Minutes to Find Information	Percent Who Used	Percent Users Who Found Effective
Human	24	68	82
Printed	10	62	74
Online	9	69	71

DISCUSSION

Our objective was to determine what information sources computer users employ currently to help them solve computer-use problems. A computer-use problem occurs when, in the course of doing a task with the aid of a computer, a user either a) can not make the computer equipment work (for example, a printer), b) does not understand a computer concept (for example, a data set), or c) does not understand the relationship between a computer concept and a task concept (for example, the relationship between a system data-set record and a person's account file). Computer users have a number of help sources at their disposal. We have categorized these into 3 major access and delivery systems:

1. Users can ask a question of another person, that is, another user, a supcnisor, or a consultant.
2. A reference manual or other hard copy document can be examined.
3. An online help facility can be accessed and items of perceived relevance can be selected and read.

[2] The critical value of chi-square for p = **0.05 with 2 degrees of** freedom is 5.99.

Sources in each of the categories provide different information in different manners, and possess different characteristics. These factors partially determine when each will be selected and what success will be achieved.

Each category of source has its own advantages and disadvantages. Another person has the advantage of being able to engage in flexible and diagnostic dialogue. Thomas and Carroll [13] outline the power of this capability. Potential disadvantages of using another person for help include the variable degrees of knowledge people possess about computers and the task the user is trying to perform. Furthermore, another person may not be available at the time the problem is confronted. Typically, a reference manual has the advantage of being the most comprehensive and complete source of information. However, it has the disadvantages of requiring the help seeker to know a) what piece of information is being sought in the precise terminology and indexing scheme of the manual, and b) how to search the manual for it. Similar to people, manuals are not always available to users in the problem situation. Online help has the advantage of always being available to computer users. Houghton's review [10] outlines the range of characteristics that online help facilities possess, and cites the presentation of too much information--"drowning" the user--as the most frequently occurring disadvantage.

Table 4 summarizes our assessment of how the categories of help fall on three characteristics that summarize the advantages and disadvantages of each. Assuming it is installed, online help has uniformly high availability, because it is available when the system is. In contrast? human and documentation help have varied availability. Because it can be complete and comprehensive, documentation typically has a high effective depth of knowledge. In contrast, the depth of knowledge 'of a human source ranges from expert consultants to first-time users with no knowledge. For online help it ranges from obscure error messages, which sometimes have no relevance to the specific error,[3] to online documentation and manuals. Humans have a uniformly high level of diagnostic and selection capabilities. Even in cases where they do not have the expertise, knowledge, or information to answer a question, humans can say so, thus sparing the help requester the effort of coming to the conclusion that an online help panel or a chapter in a reference manual does not apply to the problem. Documentation most often relies on the users' skills and abilities to diagnose what information is required, and select the appropriate sections to find it. Some documentation now comes with sections describing the selection process, but almost none comes with descriptions of the diagnosis process.[4]

Table 4. Summary of Characteristics of Three Types of Help Sources

Source	Availability	Depth of Knowledge	Selection/ Diagnostic Capabilities
Human	Varied	Varied	High
Printed	Varied	High	Low
Online	High	Varied	Low to medium

Many factors, specific to the user, influence what source of help will be chosen and how successful it will be. For example, Gilfoil found users seek general help in the early stages of learning and more specific help in the later learning stages. Our findings partially support Gilfoil's result. In identifying different cognitive states, we can proceed along a learning continuum from little knowledge to mastery of a domain area. In the present study, cognitive state refers to the level of understanding the user appears to have achieved in the application domain before encountering the problem that was described in the questionnaire. We identified three cognitive states:

Learning The user is acquiring new concepts, relationships, and/or nomenclature for use in the problem domain--the building blocks for subsequent construction of cognitive structure. Users know the least about the problem and the problem domain when in the learning state.

Solving The user knows all critical concepts, but needs to build a new cognitive structure to solve the specific problem now encountered. In the problem solving state, users have most of the required cognitive elements or 'building blocks", but must put them together in a new way in order to solve the problem.; Problem solving represents an intermediate level of what the user knows about the specific problem.

Refreshing The user needs to activate a previously constructed, but now dormant cognitive structure. In the refresh state, users already know what they need to know about the problem, and have most likely already solved it once before. They just need to have their memories jogged to bring the solution back to mind. Refreshing represents an advanced level of what the user knows about the specific problem.

[3] **For example, in an implementation of Pascal, omitting the '*)' to close a comment initiates the message, 'END; STATEMENT MISSING.'**

[4] **See, for example,** Houghton **pg. 130, which describes some online help facilities as being differentially sensitive to user** information **needs, and can accordingly select information to display.**

Having identified both cognitive user states and related levels of knowledge integration, we can proceed to interpret our other findings from this perspective. In examining user behavior on an experience basis, we can trace selection of information sources and satisfaction with them in a recognizable pattern. Initial behavior of the new user begins with trial-and-error learning. Different sources are tried, subjective probabilities are developed, and assessments about the utility of specific sources are made. The user is task oriented and goal driven. Many sources are tried and are relatively quickly discarded when they cannot produce the right response.

Knowledge sources are identified and exploited for their potential in providing appropriate information to an explicit-situation confronting the user. The user is continually making judgements about available information sources for both present and future needs. The migration of the user to different information sources represents a sequence of learning stages through which a user progresses. Initially, the user recognizes a need for external support to compensate for a lack of self-direction. As the degree of self-direction increases, the type of support that is chosen reflects the amount of self-knowledge that a user can bring to the problem. Hence, when the user's knowledge is low, there is high dependency upon human sources to provide the type of support that structures the user inquiry. The human information source provides the required direction to assimilate the user-supplied data, In the final stage, the degree of user knowledge is high with a well developed structure. The experienced user is able to evaluate now the data much more meaningfully. Furthermore, the user has internalized a knowledge base to structure and easily interpret future situations without external support and direction.

What we have been developing here originates from the psychology of learning. Until it is recognized that the problems of online information and documentation are not exclusive issues of data processing or information organization or documentation writing skills, we will continue to see the types of user behavior here described and make no significant gains in improving the effectiveness of presently available sources. From our standpoint, the central issue is the psychology of learning in all its aspects and variations. Until we recognize and accept this fundamental concept, we will not make any significant, long-lasting improvements nor will we gain any meaningful understanding or insight into online information and documentation.

Seen in this light, the major point of the present study is that users, engaged in performing work activities at a computer terminal, seek out information because they are trying to learn or re-learn something pertinent to the task at hand. This seeking behavior is purposeful and directed towards maximal gain, that is, a user will experiment with several available sources and chose those that provide the most 'satisfying answers consistently and in the least time. Consequently, if the present approach to information development is maintained, then users will come to rely even more on human information sources, since human sources are currently perceived as providing maximal gain.

Unless we exploit and incorporate the characteristics examined and discussed in this report, the present situation will be exacerbated for assistance facilities. The recognition of alternative online information delivery systems with characteristics incorporating learning principles is a paramount need in improving the effectiveness of these systems for computer users.

CONCLUSIONS

Human information sources were used most frequently and rated as most effective. Online information sources were rated lower than human and printed information. The rank order of effectiveness was the same in both the general results and the specific results for learning and problem solving. Comparing human and online information sources, one can see four major areas of difference:

1) Humans are *interactive. They* engage in "give and take" dialogue, which accounts for the context of the conversation, and the pragmatic goals. Humans are very sensitive in perceiving a wide range of cues in a conversation. Furthermore, in response to these linguistic, visual, and auditory cues, humans can quickly change the conversation to meet immediate requirements. With their capabilities of natural language dialogue, humans can tailor statements to maximize the degree of interaction. No machine currently can match this capability for intensive interaction in real time.

2) Humans are' selective. A human consultant can provide only the information required; other, irrelevant information can be excluded. The user is not bombarded automatically with every piece of information about a topic.

3) Humans can engage in *query* at multiple levels of dialogue. The user can ask the human consultant questions to define terms and clarify ambiguities at many levels.

4) Humans can make *assessments*. A human consultant can ask the user questions to ascertain the level of understanding and diagnose difficulties.

Humans have definite advantages over machines in these areas. These advantages account for the increased effectiveness ratings given to human information sources.

Two conclusions about user factors are implied by the study results. First, the study shows that user cognitive states can be identified. Second, the results indicate that the users who are learning and solving problems have more complex information requirements than do refreshers. To be effective for all users, online information must account for the user cognitive state and the increased complexity of learning and problem solving. This underscores the need for intelligent advisory systems as described by Carroll, McKendree, and Aaronson [1, 2, 4, 5].

The three user cognitive states identified in the situation descriptions each have unique characteristics. *Learning* is where the user must acquire new concept, relationship, term, or skill in order to proceed with a task. For example, an experienced system programmer may have to learn a document composition facility to prepare program documentation. *Problem solving* is where the user has already mastered fundamental concepts, relationships, terms, and skills, but must compose or integrate them in a new way in order to proceed with a task. For example, a FORTRAN programmer with extensive experience in numerical programming may have to solve a problem of writing a simple parser in FORTRAN. *Refreshing* is where the user has previously performed a task, but refers 'to an information source as a memory aid on how to complete it. For example, a manager may have to refer to notes from the previous time an electronic message was sent to another site. Online information should be designed to account for the different characteristics.

In the study refreshers appeared to know exactly what information was required, and where to find it. In contrast, learners and solvers faced a more complex situation involving a less well directed search through varied information sources. Learners tried more information sources than solvers and refreshers. Learners and solvers required significantly longer to find the information than refreshers. Learners appear to be less focussed in their search for information. Because they require significantly more time to find information than refreshers, both learners and solvers could benefit from increased information selectivity and guidance in searching for information. Significant design effort for online information is required for the learning and problem solving situations.

In conclusion, the study clearly indicates that the user's cognitive state has significant effects on the use and effectiveness of information sources. Online information sources should therefore be designed to account for the user cognitive state. This is a significant research and engineering challenge, but one with a definite payoff: Obtaining the information from a human source requires more than twice the time as do online and printed sources. This study suggests that online information sources can be significantly improved if they are made more interactive, incorporate features for better selectivity of information, are more oriented towards a query format, and contain some degree of assessment capability.

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