

# A Comparison of Web Searching and Library System Searching: Perceived Difficulty, Self-Efficacy, and Effort\*

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### ABSTRACT

The purpose of this study was to explore whether the concept of amount of invested mental effort (AIME) developed in the field of educational psychology can help explain why people put so little effort into online searching. In this experimental study, two information retrieval systems - a web search engine and a university library system - were used to make a comparison. The data were collected from 15 undergraduate students through background questionnaires, think-aloud protocols, search logs, post-search questionnaires, and post-task interviews. The findings indicate that perception of the web's "easiness" and high levels of self confidence in searching capability led the subjects to put less effort into web searching than they do into library system searching. In addition, the perceived difficulty of search task influenced the extent of mental effort invested. The AIME proved a useful framework for understanding search behavior and user experience for both web search engines and library systems.

### 초 록

본 연구는 왜 이용자들이 정보탐색에 많은 노력을 기울이지 않는가를 알아보기 위하여 교육심리학분야에서 개발된 정신적 노력에 관한 개념을 웹 검색엔진과 도서관시스템 정보탐색행위에 적용하여 보았다. 실험실 환경에서 학부학생 총 15명을 대상으로 탐색실험을 실시하여, 탐색전 설문조사, 탐색후 설문조사, 탐색후 인터뷰, 생각 소리내어 말하기 (think-aloud), 로그데이터를 통하여 데이터를 수집하였다. 연구결과, 이용자들은 웹 검색엔진을 도서관시스템에 비하여 훨씬 쉽고 인지하며 스스로 탐색에 대한 높은 자신감을 가지고 있었다. 이러한 이용자성향은 이용자들이 웹 탐색에 도서관탐색때보다 더 적은 노력을 기울이는 것과 깊은 연관성을 가지고 있는 것으로 나타났다. 이용자들의 정신적 노력에 관한 개념은 결과적으로 이용자들의 정보탐색 행위와 경험을 설명하는데 매우 유용한 것으로 밝혀졌다.

Keywords : web searching behavior, mental effort in searching, self-efficacy in searching  
웹탐색행위, 도서관정보탐색행위, 정보탐색노력

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## 1. Introduction

Since the mid-1990s, web searching has become a highly popular activity that people perform on a daily basis. There seems to exist a fair understanding of how people conduct web searches in search engines: they conduct brief search sessions (2.4 queries per user), enter short queries (2.5 terms per query), and view a small number of pages (1.7 pages per query). Rarely, do they use Boolean operators and other advanced features for web searching (Silverstein et al., 1999; Spink, Jansen, Wolfram, & Saracevic, 2002; Spink & Jansen, 2004). Considering how much searching people are doing today, one can presume that they have become effective searchers who know how to use the advanced features of search engines, where to find good search terms, and how to reformulate their queries. It appears, however, that their web searching behavior has not changed a lot for the past ten years.

The concept of mental effort can play a key role in better understanding people's simple web searching behavior. For instance, if people perceive that web searching is too easy, they might put little effort into searching. If, however, they believe web searching is serious and demanding, they might invest considerable effort. This research examines the problem of performing simple searches on the Web by comparing people's effort exerted in two information retrieval systems: a Web search engine and a library system.

Web search engines and online library systems provide good examples for making a comparison of searching behavior with respect to effort. While both are designed to help people find information, they may be perceived by users as different kinds of system. Online public access catalogs (OPACs) used to be "the most widely available automated retrieval systems and the first that many people encounter" (Borgman, 1996, p. 501). Given the increased use of the web in recent years, this assertion may no longer be true. Today, when people need information, they will turn to the web first despite the fact that library systems provide more authoritative information than the web (Jones, 2002).

There is a more fundamental difference between web search engines and library systems. Historically library systems have been designed to be information retrieval (IR) systems. Thus, the primary reason for people to choose the library system is to search for information. The web is, on the other hand, a much more diverse medium. People select the web not only for information retrieval purpose but also for entertainment, news, and communication. Thus, even though people select a library system or a web search engine for the shared purpose of finding information, the perceptions that they bring into the system can differ. People may feel that the web is friendly, easy, and fun whereas the library system is serious, difficult, and demanding to a degree that requires effort and

concentration (Fast & Campbell, 2004).

This research addresses the following research questions:

- How do perceptions of library systems and web search engines differ?
- How do perceptions of system and self-efficacy affect the effort invested into searching?
- To what extent does mental effort influence online searching behavior and user experience?

## 2. Conceptual Framework

Educational psychologists have compared learning experience in television viewing to reading and found that people put less effort into television viewing than reading because they consider television to be easy and "lifelike." (Cennamo, 1992-1993; Krendl, 1986; Salomon, 1984). As a result, people learn less from watching television than from reading a typescript of the same story (Salomon, 1983, 1984). Salomon (1981) introduced the concept of AIME (Amount of Invested Mental Effort) to explain this differential investment of mental effort in television viewing and reading. According to Salomon (1984), learners will invest greater effort in processing material when they encounter complex, ambiguous, incongruent, or novel stimuli that cannot be easily accounted for by their existing mental schema. On the other hand, little AIME would be warranted if learners perceive certain material to be easy.

Salomon identifies two factors closely related to AIME: Perceived Demand Characteristics (PDC) and Perceived Self-Efficacy (PSE). The perceptions that people possess about media such as television, magazines, library system, or the web are called Perceived Demand Characteristics (PDC). People invest more effort in a medium when they perceive it to be "serious" or "demanding" (Salomon, 1983, p. 47). Salomon and Leigh (1984) manipulated the PDC by asking half of a group of children to watch or read a story "for fun" (low PDC) while the other half were asked to watch or read to "see how much you can learn from it" (high PDC). They found that their participants invested greater effort in stories under the high PDC condition and consequently they learned more. The study results indicate that a priori perceptions of media can directly influence the extent to which mental effort is exerted as well as further learning outcomes.

Perceived Self-Efficacy (PSE) refers to "subjective judgments of how well one can execute a course of action, handle a situation, learn a new skill or unit of knowledge, and the like" (Salomon, 1983, p. 47). The notion of self efficacy is considered important in understanding people's mental efforts because "Judgments of self-efficacy...determine how much effort people will expend and how long they will persist in the face of obstacles or aversive experiences" (Bandura, 1982, p. 123).

These three variables that education psychologists have used to explain why people learn so little from watching television appear to have strong implications for Web searching research given that has the potential to explain why people do not put so much effort into online searching (Kim & Rieh, 2005). Just as with television, the web is considered an “easy” medium because people perceive it not only as information systems but also communication and entertainment media (Madden, 2003). Fast and Campbell (2004) conducted an exploratory study about university student perceptions of searching on the web and web-based OPACs and found that most participants were confident that the web had what they were looking for or had information that would be useful to them. Students were also confident in their ability to search the web. Undergraduate students in particular showed less self-confidence in their ability to search the OPAC effectively given their lack of experience. Many students, however, described web searching as “fast,” “easy,” and “convenient.” Most students felt the OPAC required more complex interactions than Google.

Taking the previous studies together, the variables used in Salomon’s AIME framework can be modified slightly to illustrate AIME in online searching. The perceived difficulty of searching and perceived self-efficacy in searching will influence the extent of the effort that people will invest in searching. Then the

level of mental effort will influence the ways in which people look for information (search behavior) and shape the experience they will have in a particular information retrieval system (user search experience).

### 3. Research Design

An experimental study was designed to examine the variables of AIME, PDC, and PSE. The subjects conducted a total of four searches, engaging in two given tasks in two systems. For the library system condition, the UM Library (UML) gateway site was used (<http://www.lib.umich.edu>). For the web condition, any search engine that the subjects would usually use for searching was permitted. The two tasks used in this study represented the most typical search problems for each system: Research Task on a library system and Product Task on the web. The tasks were presented in written form as follows:

(1) For this task, I would like you to do a search for your term paper topic. If you’ve already done some research, just pick up from where you left off. Don’t repeat searches you’ve done in the past [Research Task].

(2) You want to buy a new digital camera and you need to decide which model you would buy. You would like to read some reviews about digital camera to help you make a decision [Product Task].

Search conditions were randomized by allowing each subject to pick the order

of their four searches. There were eight different conditions in terms of the combinations of two systems and two tasks, and each condition was written on a small piece of paper. Sixteen pieces of papers were prepared, folded, and put in a small cup, and every time the subject came into the lab she or he picked one piece of paper from the cup in the process determining the search order.

Data were collected from multiple

sources, combining background questionnaire before searching, think-aloud protocols during searches, post-search questionnaire after using each system, post-task interview after all searches were completed, and search logs that captured the entirety of search sessions. A background questionnaire asked for demographic information, general search experience, subjects' perceived difficulty in searching on the

(Table 1) Subject profiles and their research topics

Subject #	Class rank	Major	Gender	Topic for Research Task
001	Senior	Biology/Pre-Med	M	Evolution of the human immune virus
002	Senior	Sociology	F	AIDS in Uganda
003	Senior	General studies	M	Lateralization
004	Junior	General studies	M	Violent media effects on people
005	Freshman	Undecided	M	Gods and their roles in ancient Greece
006	Sophomore	Biology	M	Databases for the automotive industry to determine their data mining process for recalls and safety procedures
007	Freshman	Undecided	M	Data mining techniques
008	Sophomore	Psychology	M	Student activism during the Vietnam War
009	Senior	Biopsychology	M	Constructive use of disparate data
010	Freshman	Political Science	M	Some pitfalls and bonuses of databases used on the web to track customers, criminals, etc.
011	Senior	French	F	Business analysis of a French company, from history to management and financials
012	Freshman	Nursing	F	A method in which data mining techniques are being used applied to accomplish the constructive use of disparate data
013	Freshman	Undecided	F	A health issue that is relevant to women from a feminist perspective
014	Senior	Economics/Psychology	F	European Customs Union
015	Sophomore	Business	M	How recent technological developments have effected the storage and use information

web and on the UM Library system, their self-confidence in using online systems, and their perceptions of each search task (Product Task and Research Task). A post-search questionnaire collected information about the difficulties encountered in searching, effort put into searching, usefulness of search results, importance of the search, and other learning and searching experiences. A post-task interview was designed to gather data about their familiarity with the topic, difficulty of searching in various stages of the search process, system preferences, and attributes of success and failure in searching.

The researcher posted flyers in university buildings where undergraduate students gathered for leisure or academic activities. In the flyer, the researcher sought students who had been given a term paper, course assignment, or project that required the use of library resources. Fifteen

undergraduates who responded to the flyer subsequently participated. The volunteers were five freshmen, three sophomores, one junior, and six seniors. Ten were male and five were female. Their major areas were rather diverse: biology, sociology, psychology, French, nursing, business, and political science. Even though subjects were undergraduate students, the topics that they selected were appropriate as Research Task. Topics include evolution of the human immune virus, violent media effects on people, Gods and their roles in ancient Greece, student activism during the Vietnam War, business analysis of a French company, and women health issues from a feminist perspective. <Table 1> presents the profiles of subjects and their research topics. They received monetary compensation for their participation in the one-hour session.

The computer used for the experiments

<Table 2> Definitions of measures and characteristics

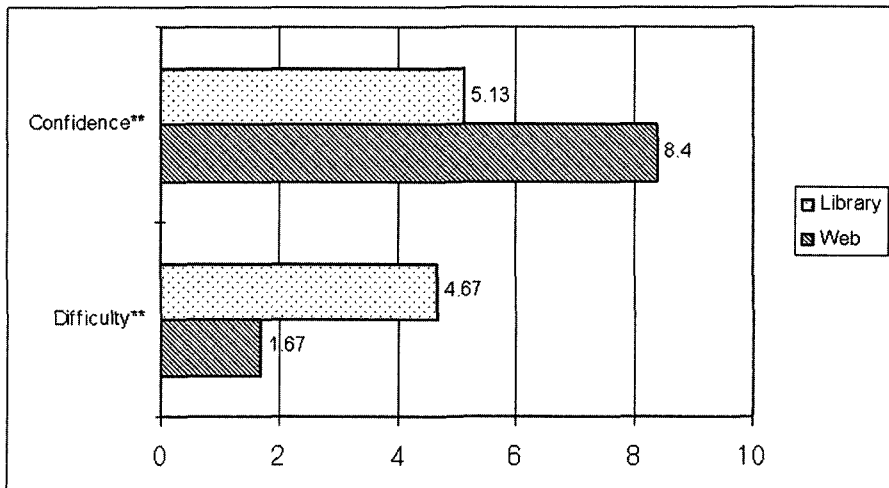
Measures/Characteristics	Definitions
Time for Initial Query Formulation	Time taken for a searcher to formulate the first query
Time to view search results	Time taken for a searcher to view the displayed search results in total
Time to read documents	Time taken for a searcher to read full texts retrieved
Clicks in total	Total number of clicks per search session
Selection of search results	Total number of search results selected by a searcher per session
Documents read	Total number of full-text documents read by a searcher
Printing/emails	Total number of full-text documents printed or emailed by a searcher
Terms in the first query	Number of words entered by a searcher for the first query
Terms in average	Number of words in average per query entered by a searcher
Query reformulation	Total number of query reformulations per session
Advanced Features	Total number of uses of advanced features per session

was a Dell PC equipped with a Premium 4 CPU 2.40 GHz processor and 256 MB memory operating under Windows XP Professional and a 17" color monitor. Internet Explorer Version 6.0 was used as a web browser. Camtasia Studio Version 2.0.2, software for capturing PC desktop activity, was used to save search logs.

The procedures taken in the experiments are as follows. Upon arriving at the researcher's office, the subjects signed a consent form and completed a background questionnaire. After that, they received general instructions that applied the four searches to be assigned. They were allotted 10 minutes to complete each search. During their searches, subjects were asked to think aloud about what they were doing and why. Camtasia saved search activities to desktop movies and an audio tape recorder recorded subjects' think-aloud verbal reports. Each time

the subjects completed a search, they filled out a post-search questionnaire to report difficulties they encountered in their searching, effort, and other search experiences. After the subjects finished a task using the two systems, a post-task interview was administered to learn more about their searching experiences with respect to the comparison of searching experiences.

For the all 15 subjects, the tapes of the think-aloud and interview recordings were transcribed, and content-analyzed. The search logs saved as Camtasia files were played back and analyzed using a coding scheme developed by the researcher. The coding scheme attempted to record search characteristics as shown in (Table 2).



(Figure 1) Preconception of search difficulty and self-confidence

## 4. Results

### 4.1 Perceived and Actual Difficulty in Searching

The study findings indicate that the subjects had significantly different levels of self-confidence and perceived difficulty for web searching and library system searching. According to the responses of the Background Questionnaire administered before the subjects began to conduct searches, the subjects were significantly more confident with respect to web searching (M=8.4, SD=1.24) than library system searching (M=5.13, SD=2.87),  $t(14)=4.23$ ,  $p < .01$  on a scale of 0 (not confident) to 10 (very confident). As presented in Figure 1, the subjects also perceived that library system searching

would be significantly more difficult (M=4.67, SD=2.16) than web searching (M=1.67, SD=2.09),  $t(14)=4.3$ ,  $p < .01$  on a scale of 0 (not difficult) to 10 (very difficult). In comparison of the perceived difficulties before and after searching, it was noted that the perceived difficulties for library searching remained at the same level (pre-search M=4.67; post-search M=4.97) whereas web searching proved to be somewhat more difficult (M=3.1) than the subjects initially expected (M=1.67).

In terms of comparing two tasks, the subjects expected that the Research Task (M=5.33) would be more demanding than the Product Task (M=2.93). After the subjects conducted searches, they filled out a post-search questionnaire on experienced difficulty in various stages of the search process. <Table 3> presents

<Table 3> Comparison of post-search perceived difficulty

Questions	Product Task		Research Task	
	Web M (S.D.)	Library M (S.D.)	Web M (S.D.)	Library M (S.D.)
Difficult to start the search (P:**, R:*)	1.06 (1.62)	6.0 (3.16)	2.2 (2.3)	4.47 (2.85)
Difficult to think of keywords to enter into a system (P:**)	1.07 (1.27)	5 (2.78)	4.33 (2.87)	5.66 (3.04)
Difficult to formulate search query (P:**, R:*)	1.13 (1.35)	5.13 (2.47)	3.53 (3.0)	5.53 (2.85)
Difficult to understand search results (P:**)	2.33 (2.89)	5.6 (2.44)	4.53 (2.92)	4.47 (3.16)
Difficult to make decisions about usefulness of search results	3.27 (3.08)	4.8 (3.21)	4.67 (2.63)	4.87 (2.90)

Note: A scale of 0 (not difficult, no effort, no thinking, not concentrated)– 10 (very difficult, great deal of effort, great deal of thinking, very concentrated). \*\* indicates  $p < 0.01$ , \* indicates  $p < 0.05$ . P refers to Product Task, R refers to Research Task.



the details of the subject responses after search completion. Overall, the subjects reported that they did not have much difficulty in finding information when using search engines but experienced some difficulties in using the library system.

Notably, the difficulty experienced on web searching and library system searching differed significantly in various stages of searching including getting started on the search, entering keywords, formulating search queries, and understanding search results. However, little difference was noted in the two kinds of searching when the subjects attempted to make decisions about the usefulness of search results. It was also worth noting that the differences in the perceived difficulty of the two systems were more apparent for the Product Task than the Research Task. This result appears to be related to the fact that the subjects perceived the Product Task to be less demanding than the

Research Task. In other words, the subjects were more fully aware of the differences in searching for the two systems when they dealt with an easier task than a difficult one.

#### 4.2 Mental Effort invested into Searching

The type of task (Research Task vs. Product Task) also mattered in the extent of effort that the subjects put into searching. Again, the difference between two systems was more obvious for the Product Task than the Research Task. When the subjects engaged in Product Task, they invested significantly more efforts into library system searching (M=6.8, SD=1.97) than into web searching (M=4.53, SD=2.8),  $t(14)=2.79$ ,  $p<.05$ . They also responded that they had to think more when searching on the library system (M=6.73, SD=2.15) than on the web (M=3.87, SD=2.42),  $t(14)=3.08$ ,  $p<.01$ .

Interestingly, when the subjects engaged

(Table 4) Comparison of mental effort

Questions	Product Task		Research Task	
	Web M (S.D.)	Library M (S.D.)	Web M (S.D.)	Library M (S.D.)
Effort invested into searching (P:*)	4.53 (2.80)	6.8 (1.97)	6.06 (2.15)	6.67 (1.84)
Thoughts put into searching (P:**)	3.87 (2.42)	6.73 (2.15)	6.33 (1.99)	6.6 (1.99)
Concentration during the search (P:**)	5.27 (2.54)	7.4 (1.68)	6.73 (1.75)	7.13 (2.03)

Note: A scale of 0 (not difficult, no effort, no thinking, not concentrated)– 10 (very difficult, great deal of effort, great deal of thinking, very concentrated). \*\* indicates  $p<0.01$ , \* indicates  $p<0.05$ . P refers to Product Task, R refers to Research Task.

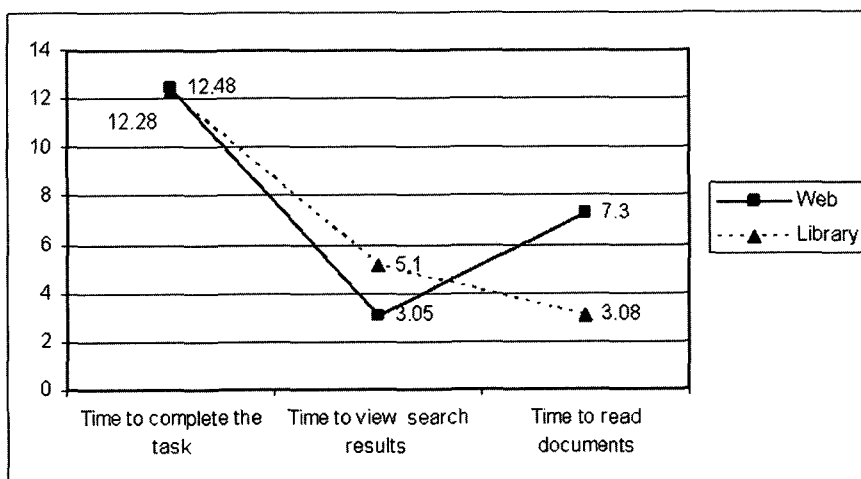
in searching for their term-project (Research Task), they responded that they had to put more or less the same effort and thought into searching across two systems: efforts invested (library M=6.67 and web M=6.07) and thoughts put (library M=6.6 and web M=6.33). They also reported concentrating on library system searching (M=7.13) to a somewhat greater extent than on web searching (M=6.73), but the difference was insignificant.

### 4.3 Characteristics of Search Behavior

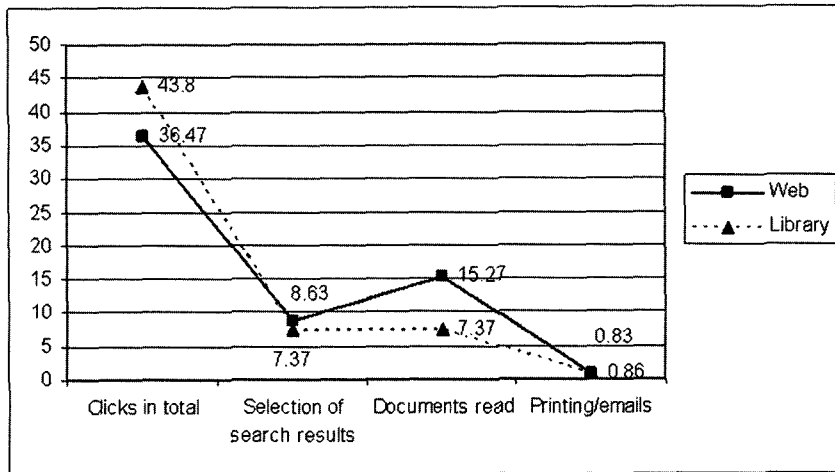
The characteristics of search behavior were compared between the library system and the web search engines to examine differences in mental effort in terms of search interactions measured by time taken and frequencies occurred. Given the research design that allotted 10

minutes for each search session, the time taken to complete the tasks did not differ between the systems. Most subjects entered their first query within the very short time of 0.15 minutes. (Figure 2) presents that the subjects spent more time in viewing search results (5.1 minutes) than reading actual documents (3.08 minutes) on the library system. When the subjects interacted with the web, they spent more time in reading documents (7.3 minutes) than viewing search results (3.05 minutes). As a result, the time taken for the subjects to view the displayed search results appeared to be longer on the library system than on the web. The subjects spent longer time on the web than on the library system to read full texts.

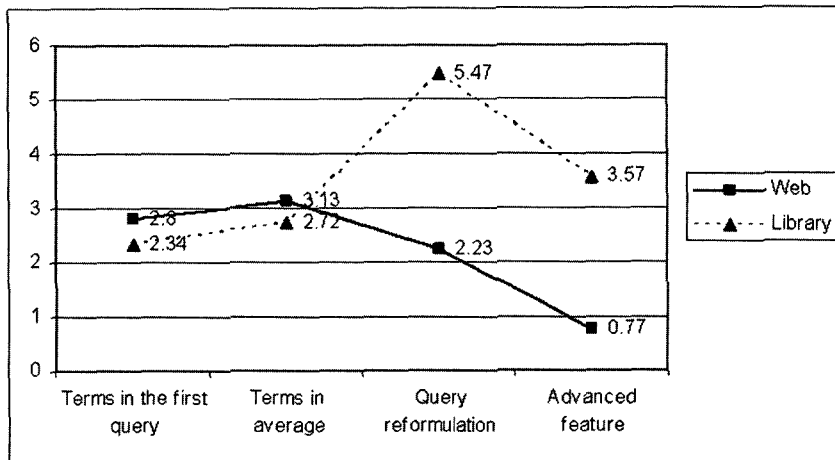
To complete tasks, the subjects had to click on considerably more links on the



(Figure 2) Comparison of effort in time taken



⟨Figure 3⟩ Comparison of effort in search interactions



⟨Figure 4⟩ Comparison of effort in query formulation behavior

library system (43.80 clicks per session) than on the web (36.47). They also read more documents on the web (15.27) than on the library system (7.37), selecting slightly more search results on the web (8.63) than on the library system

(7.37). The differences of search interactions between the two systems are summarized in ⟨Figure 3⟩.

Mental effort was also examined based on search behavior with regard to query reformulation. As shown in ⟨Figure 4⟩,

query terms entered by the subjects were slightly longer on the web than on the library system. However, the subjects seemed to make much more effort in library system searching than in web searching as they reformulated their search queries to a greater extent, reformulating queries 5.47 times on average on the library system and 2.23 times on the web. They also used advanced features of searching more frequently on the library system (3.57) than on the web (0.77).

#### 4.4 User Experience in Online Searching

The interface of the UM Library's gateway system includes links to diverse library resources such as online catalogs, electronic journals and newspapers, and networked electronic resources among others. As a result, library users "did not know where to go and where not to go." Interestingly, the subjects did not solve the complexity of interface by simply putting more effort into searching on the library system. Especially when the subjects searched for the Research Task, they did not put more effort, thinking, and concentration into library searching than into web searching. Rather, they frequently expressed their emotions toward the library system by using terms such as "complicated," "overwhelming," "confusing," "hard to understand," and "difficult to use." In contrast, they reacted to the web positively, saying that the web was "easy" and "familiar" and that

they were "willing to explore" and "enthusiastic." A subject explained different user experiences as follows: "There's one [web] search engine that will search everything and most people are familiar with it. Compared to the library one where they have tons of networked electronic resources that are there for different things. It's not just one encompassing it all. And I think that's where it makes it a lot easier on the web."

It turns out that the reason they talked about the two systems differently was more often related to their initial expectations of a system rather than to the search results. Although contemporary library offers a variety of electronic resources including full texts, the subjects' expectation toward the library resources seemed to be somewhat limited. One subject said "But I don't know how helpful that will be because I just think they're going to give me the books but I'm going to try it anyway." Another subject also remarked: "The problem with Mirlyn [University of Michigan library system] is obviously I really can't get any information right now. I would have to go to the library to pick up the books so I'm not really sure how helpful this is going to be for the final project."

The results reveal that differential expectations of the two systems affected subjects' search experiences directly. Because most subjects believed that the web was easy to use, they tended to blame themselves when their web

searching ended unsuccessfully. On the other hand, when their searches of the library system failed, they blamed the library system itself and especially its interface design. For instance, a subject said, "Well I would be more prone to blame the Mirlyn [UM Library's OPAC] website than the student at first just because the format for it is just not a very good interface for someone who is trying to search for something specific."

One of the questions asked during the post-task interviews sought to identify the reasons for successful searches and failed searches. This question was asked in such a way that the subjects could explain it as someone else's experience. For instance, a question asked was: "Let's say that a student like you searched on the web to find review information for buying products and was very successful in finding useful information. What were the reasons for his or her success?" The same question was asked with respect to both the web and the library system just after they completed searches for each task. Many subjects said that entering good keywords was the most important factor contributing to successful web searching. Good keywords often mean a proper level of specificity. For example, one subject claimed that "It's a kind of like a fine balance. You can't get too narrow in your search but you can't be too wide either and then you can't find anything." With respect to the Product Task, they identified the reasons for their successful

web searching in terms of finding the right places to go, selecting the best search engines, and the shopping experience on the web. When the subjects stated their reasons with respect to the Research Task, their evaluation of the value of the web information appeared to be important factors as they alluded to obtaining "real" or "reliable" information, and not "junk." The common reasons identified as important factors for their failures on the library system included that they did not know where to go and where not to go. In other words, selecting appropriate databases or online catalogs on the web-based library system posed a uniquely challenging problem in library system searching.

#### 4. Conclusion

This research endeavored to identify the reasons behind people's simple searches on the web in comparison to their searches on the library system. It was presumed that simple online searching behavior is related to people's willingness to invest effort into their searching. Further, this study was concerned that perceptions and expectations of information retrieval systems as well as self-confidence in online searching capabilities would be related to the extent of the effort being put into searching and eventually characteristics of search behavior and user experience.

The results show that the perceptions and expectations that the subjects had for the web differ significantly from those for the library system. They took the library system more seriously. As a result, they invested more effort, put more thoughts, and concentrated more when using the library system. The differences of perceived difficulty, self-confidence, and effort between the web and the library system appeared to be more obvious in the Product Task than in the Research Task. This is because subjects perceived the Research Task to be more demanding than the Product Task. We can speculate that when subjects perceived the search task to be demanding, the type of information retrieval (IR) systems mattered less to them. When the search task was perceived as being easy, such as the Product Task, the perceived difficulty of IR systems seemed to directly influence the extent of effort invested. It was also noted that the amount of effort invested might not always lead to positive user experiences or successful searches. In fact, in the library system, subjects reacted more emotionally and they were more easily frustrated compared than they did

on the web. It means that subjects may not always consider mental effort as a necessary process in online searching that can improve their search results.

To conclude, the question of how people's perceptions of information retrieval systems and attendant self-confidence affects the amount of mental effort they put into online searching proved to be useful in understanding user experience on the web and in library systems. Information science researchers and system evaluators should take into account people's perceptions of information systems and self-efficacy because these factors may well impact how people use systems, the effort they expend, and their interpretations of their failure to find useful information. For instance, people's assessment may not be entirely based on current interface designs and functionalities to be tested. Rather, as the results of this study demonstrated, the perceived difficulties of system, self-confidence in performing task, and familiarity with the interface of a preferred system can all influence the way people use the system and indeed can further shape the search experience.

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