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An Analysis of Correlation Between Metacognition and Digital Library Searching Behavior

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[Abstract]

The main purpose of this study is to analyze the metacognition of digital library search behavior of college students and to provide a fundamental data for the designing a user-centered online information retrieval system to find more optimal search results. In order to achieve the purpose of this study, metacognition was classified into the five main categories, including schema-training, planning, monitoring, evaluation, and transfer, and a total of twenty subcategories were included. A total of 112 students participated in the online questionnaire. The collected data were analyzed using SPSS version 26, and it was found that there was a significant correlation between metacognition of college students and their digital library searching behavior. In particular, the digital library search experience was found to be the strongest factor to be considered as the most important variable in digital library design based on the aspect of user metacognition.

▸ **Key words**: Metacognition, Digital Library Searching, Online Information System, Interaction, Information Searching Behavior, Correlation Analysis

[요 약]

본 연구는 대학생들이 디지털 도서관 검색 행태에 대한 메타인지를 분석하고, 보다 최적의 검색결과를 찾기 위한 사용자 중심의 온라인 정보검색시스템 설계를 위한 기초자료를 제공하는 것을 목적으로 한다. 본 연구의 목적을 달성하기 위하여 메타인지를 스키마-트레이닝(schema-training), 계획(planning), 모니터링(monitoring), 평가(evaluation), 전이(transfer)의 5가지 주요 범주로 분류하였으며, 총 20개의 하위 범주를 포함하였다. 총 112명의 학생들이 온라인 설문지에 참여했고, 수집된 데이터는 SPSS 버전 26을 이용하여 분석하였으며, 대학생들의 메타인지와 디지털 도서관 탐색 행위 간에 유의미한 상관관계가 발견되었다. 특히 디지털 도서관 탐색경험은 이용자 메타인지 측면을 고려한 디지털 도서관 설계에서 가장 중요한 요소로 밝혀졌다.

▸ **주제어**: 메타인지, 디지털 도서관 탐색, 온라인 정보시스템, 상호작용, 정보 탐색 행위, 상관 관계 분석

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I. Introduction

The rapid development of Information Communication and Technology (ICT) has brought about unprecedented changes in digital libraries how we generate, collect, store, access, and use information [1]. Due to the role of ICT, libraries are undergoing fundamental changes from the traditional library to the digital library. Digital library searches become faster than traditional libraries in terms of access, tracking, and electronic resources.

Searching information from digital libraries is a deliberate endeavor to eliminate a deficiency of knowledge or to obtain information to meet the needs of knowledge. However, due to the dynamic changes in both digital libraries and websites, users experience less optimal search results or suffer cognitive overhead. This is probably due to a lack of information tailored to the users' interests, preferences, needs, context, and metacognitive awareness.

Swanson defined metacognition as an individual awareness of the ability to monitor, regulate, and manage their learning activities [2]. In other words, metacognition refers to higher-level planning for handling a learning activity and mechanisms for observing and evaluating comprehension. At times, individuals utilize the expression "going meta" when discussing metacognition, alluding to the interaction of reviewing a sort of flashback to see what you are doing, as though you were another person noticing it.

Sternberg describes to these executive processes as meta-components in his triarchic theory of intelligence [3]. According to him, metacomponents are in charge of determining how to perform a certain task or set of activities and then ensuring that the job or set of tasks is completed correctly and the ability to organize cognitive resources effectively, such as selecting how and when a task should be completed is centered to intelligence. Therefore, metacognition is a fundamental human trait that is defined as thinking about thinking by going through a process of review [4].

Having metacognition awareness assists individuals in taking a more active role in planning, analyzing, evaluating, and monitoring their learning processes [5]. According to Flavell, metacognition is the act of a thinker reflexting on their mental process [6]. Metacognition is assumed to play an essential part of understanding users behavior in their information searching by structuring the searching process, monitoring, and assessing much as it is in the learning process. More in-depth analysis studies are needed to understand the relationship between metacognition and the search process and its applications. So much research has been done in the academic field, but much research has not been done in the web information searching strategies regarding metacognitive skills.

Therefore, the main purpose of this study is to analyze the metacognition of search behavior for digital library and to provide a fundamental data for designing user-centered online information retrieval system to find more optimal search results based on user metacognition aspects.

II. Related work

Gorrell et al. conducted a research on metacognition uses in information retrieval systems [7]. They classified metacognition components into five categories, such as schema-training, planning, monitoring, evaluation, and transfer. They used metacognition information Likert-based knowledge generator, so called MILK. They found that people use metacognition vary greatly depending on gender, age, and academic discipline and that older adults, in particular, use metacognitive skills more than younger adults.

Madden et al. revealed whether the application of user evaluation standards provides metacognitive evidence for web reliability, a total of 48 graduate students from various disciplines participated in the study [8]. They found that students who participated in the study appeared to have little formal assistance on the evaluation which provides

the most direction indication of metacognition behaviour.

Cadamuro et al. investigated the relationship between metacognition and the e-learning environment using online course in undergraduate students [9]. They found that students reflected metacognitive skills while participating in online courses to build advanced epistemic agency and enhance decision-making skills through metacognitive tips.

Reisoglu et al. analyzed 20 university students on online information searching and metacognitive abilities during argumentation activities, focusing on three phenomena, such as argumentation activities, metacognitive skills, and the link between them [10].

By examining screen recordings and the online information searching strategy inventory (OISSI) created by Tsai, different results were obtained in terms of metacognition and online information searching methods [11]. The findings of the interviews demonstrated a link between users' online information searching tactics used in argumentation activities and all dimensions of metacognition. Furthermore, the data shows that metacognition skills are frequently linked to multiple sub-dimensions in framework and might readily encompass a variety of techniques.

Searching activities can be argued to allow for extensive use of metacognitive abilities in planning, monitoring the information gathering process, and applying appropriate strategies. Therefore, metacognition is essential in solving complicated digital library searching problems.

III. Methods

1. Participants

This research employed a simple random sampling technique in selecting one hundred and twelve respondents for this research. This includes 20 Korean students, and 92 International students in a university. Of them, 57 percent were males 43 percent were females. The age of participants ranges from 18 years old to 43 years old above, and the qualifications are different from bachelor's, master's, PhD, and postdoctoral courses with experience in K-university digital library.

2. Metacognition Variables

In this work, five metacognitive components, i.e, schema-training, planning, monitoring, evaluation, and transfer were adopted from Brown [12].

2.1. Schema-training

This involves the development of cognitive structures that provides a conceptual framework for comprehension [13].

2.2. Planning

This refers to carefully evaluating the current situation in order to determine potential causes of action to implement solutions to achieve results and make efficient use of the time and resources [14].

2.3. Monitoring

This is about the person's awareness of how she performed in relation to the process that was planned [15, 16].

2.4. Evaluation

This refers to how the person evaluates both the organization process and the outcomes of her own learning [15. 16].

2.5. Transfer

It refers to the process of moving one's skills and knowledge from one problem-solving scenario to another. The low and high-road theory on learning transfer, developed by Perkins and Salomon [17].

Wallace and Kupperman explores web searching, recommends breaking down the rest of the required skills into two parts as task and technology [18]. In addition, Brown categories memory and comprehension as the sub-areas of metacognition [12].

In this study, these five components applied to four sub-categories were composed of a total of 20 variables, including S-M, S-C, S-Ta, and S-Te, and so on as shown in Table 1.

Table 1. Metacognition variables

	Memory	Comprehension	Task	Technology
Schema-training	S-M	S-C	S-Ta	S-Te
Planning	P-M	P-C	P-Ta	P-Te
Monitoring	M-M	M-C	M-Ta	M-Te
Evaluation	E-M	E-C	E-Ta	E-Te
Transfer	T-M	T-C	T-Ta	T-Te

Based on these variables we developed a questionnaire consisting of 32-items using the Google forms feature. The questionnaire was aimed at addressing all the areas described in the taxonomy and exploring participants' perceptions of the use of selected metacognitive skills while interacting with websites. The measurement used is a 5-point Likert type scale range and was set out and scored in the following way 5=Strongly agreed, 4=Agree, 3=Neutral, 2=Disagree, and 1=Strongly disagree.

3. Data Analysis

The collected data were organized and processed using the social science statistics package (SPSS) version 26. Descriptive statistics of frequency count were used to provide information on the number of males and females that participated in the research. It was also used to analyze the gender, age, qualification, academic background, searching skills, and experience with online digital library searching. Mean and standard deviations were used to analyze research questions to determine how the 20 categories of metacognitive skills held when they interacting with digital library searching as shown in Table 2. In addition, bivariate correlations were used as the results shown in Table 3 to analyze the relationship between 20 categories of metacognition and demographics of digital library users.

IV. Results

Metacognitive competence scores of college students were calculated using descriptive statistical analysis. The overall mean score is 3.62 and the criterion mean is 3.0 on a five-point scale of metacognitive skills which was divided into five categories namely, schema-training, planning, monitoring, evaluation, and transfer. Group means for each metacognitive skill category were also calculated. It turned out that 'transfer' showed the most influential variables and followed by planning, monitoring, evaluation, and schema-training in descending order. Specifically, the transfer-task(T-Ta) factor was the highest overall with an average 3.99, which means that college student's experience in other areas helped them to pinpoint the type of information they needed for learning task in the digital libraries. Full results are listed in Table 2.

Bivariate correlation analysis was performed to discover the relationship between demographic factors (i.e., gender, age, qualification, academic backgrounds, searching skills, experience with digital library) and the metacognitive skills what they used during searching with digital library.

The results of the study showed that there is a negative significant relationship between gender and S-Ta (Schema-training_Task, $r = -0.261$, $p > 0.01$) as well as on P-M (Planning_Memory, $r = -0.205$, $p > 0.05$. It also showed that there is a negative significant relationship between age and S-C (Schema-training_Comprehension, $r = -0.209$, $p > 0.05$).

Furthermore, there is a negative significant relationship between academic background and S-C (Schema-training_Comprehension, $r = -0.216$, $p > 0.05$), P-Ta (Planning_Task, $r = -0.265$, $p > 0.01$), as well as on M-C (Monitoring_Comprehension, $r = -0.214$, $p > 0.05$). However, it showed a positive significant relationship between academic background and E-M (Evaluation_Memory, $r = 0.214$, $p > 0.05$).

Also there is a negative significant relationship between experience with digital library and S-M

Table 2. Results of mean and standard deviations

S/n	Types of metacognitive skills	$\overline{x}$	Std. D
	Schema-training		
S-M	I have techniques that help me remember any information I come across on digital library.	3.84	0.94
S-C	I have techniques that help me understand the information I find while using digital library.	3.21	1.19
S-Ta	I have developed ways of identifying the type of information I need for my learning tasks while using digital library.	3.33	1.24
S-Te	I am good at choosing keywords on user interface of digital library to get optimized feedback.	3.52	1.18
	Average mean =	**3.48**	**1.14**
	Planning		
P-M	I plan ways to remember the information I find in the digital library.	3.88	0.84
P-C	I may use the digital library to start a search task to increase my understanding on a subject area.	3.87	1.02
P-Ta	I decide in advance exactly what type of information I am looking for on digital library.	3.17	1.33
P-Te	I tend to work out my search skills before using a digital library.	3.65	1.02
	Average mean =	**3.64**	**1.05**
	Monitoring		
M-M	Sometimes when using the digital library, I am aware that I might forget the information I find.	3.68	1.01
M-C	Sometimes when using the digital library I may have misunderstood information I read earlier in my search.	3.04	1.14
M-Ta	When using the digital library for a learning task, I find myself asking questions along the lines of: "Is this search providing the type of information I need?"	3.94	0.80
M-Te	At times I am cautions as I search (e.g. the words I put into the search box) in the digital library.	3.85	0.91
	Average mean =	**3.63**	**0.97**
	Evaluation		
E-M	It is clear to me when I am failing to remember what I learned in the digital library.	3.49	0.93
E-C	While using the digital libraries I get convinced that the feedback of my search is valid.	3.18	1.15
E-Ta	I spend a lot of time judging how well the information I find in digital libraries matches my learning needs.	3.70	1.02
E-Te	It is usually obvious to me whether I am using a good search strategy on a digital library or not.	3.80	0.92
	Average mean =	**3.54**	**1.01**
	Transfer		
T-M	I use different approaches to recall the information that I learned in other domains of digital library.	3.77	0.96
T-C	My experience with different learning tasks has helped me monitor how well I am understanding what I read in the digital library.	3.79	0.83
T-Ta	My experience in other areas helps me to work out exactly what type of information I need for my learning task in the digital library.	3.99	0.93
T-Te	The skills I apply when using a digital library are useful in other areas of my information searching.	3.70	0.94
	Average mean =	**3.81**	**0.92**
	Overall mean = 3.62		

(Schema-training_Memory, $r = -0.308$, $p > 0.01$), S-C (Schema-training_Comprehension, $r = -0.233$, $p > 0.05$), S-T (Schema-training_Task ($r = -0.295$, $p > 0.01$), P-C (Planning_Comprehension, $r = -0.189$, $p > 0.05$), and T-C (Transfer_Comprehension, $r = -0.217$, $p > 0.05$).

There is a negative relationship between gender and schema-training and planning. This means that when interacting with digital library, male students use metacognitive skills more in categories of schema-training planning than female students. Age has a negative significant correlation with metacognitive skills in schema-training. This means that the elderly have metacognitive accuracy and that the elderly can accurately evaluate their ability to selectively remember high value-added information compared to the younger ones. This is very much the same results as what Gorrell et al. conducted [7].

There is a negative relationship between academic background and schema-training, planning, and monitoring, which shows that engineering students have a higher metacognition skills in planning monitoring than students from

Table 3-1. Results of bivariate correlations

		S-M	S-C	S-Ta	S-Te	P-M	P-C	P-Ta	P-Te	M-M	M-C	M-Ta	M-Te
Gender	Pearson Correlation	-.063	-.134	**-.261****	-.136	**-.205***	-.135	-.125	-.165	-.010	.077	-.159	-.034
	Sig. (2-tailed)	.509	.158	.005	.152	.031	.156	.190	.082	.914	.419	.094	.722
	N	112	112	112	112	112	112	112	112	112	112	112	112
Age	Pearson Correlation	-.154	**-.209***	-.103	.108	.007	-.127	-.071	-.033	.050	-.047	-.124	-.057
	Sig. (2-tailed)	.105	.027	.279	.257	.941	.181	.458	.732	.599	.624	.191	.551
	N	112	112	112	112	112	112	112	112	112	112	112	112
Qualification	Pearson Correlation	.087	-.017	-.113	.091	-.052	-.159	.071	-.001	-.011	.054	-.079	-.037
	Sig. (2-tailed)	.361	.856	.234	.342	.587	.094	.459	.991	.910	.572	.408	.696
	N	112	112	112	112	112	112	112	112	112	112	112	112
Academic Background	Pearson Correlation	.038	**-.216***	-.054	-.173	-.088	-.107	**-.265****	-.039	-.059	**-.214***	-.026	.074
	Sig. (2-tailed)	.691	.022	.569	.069	.357	.261	.005	.680	.540	.023	.784	.440
	N	112	112	112	112	112	112	112	112	112	112	112	112
Searching Skills	Pearson Correlation	.118	.083	.102	.055	-.013	-.059	.168	-.095	.033	-.080	-.007	.036
	Sig. (2-tailed)	.214	.385	.283	.562	.890	.534	.077	.320	.732	.403	.938	.703
	N	112	112	112	112	112	112	112	112	112	112	112	112
Experience with digital library	Pearson Correlation	**-.308****	**-.233***	**-.295****	-.154	-.143	**-.189***	-.099	-.180	-.036	-.021	-.073	-.087
	Sig. (2-tailed)	.001	.013	.002	.106	.132	.046	.301	.057	.707	.828	.442	.362
	N	112	112	112	112	112	112	112	112	112	112	112	112

*: Correlation is significant at the 0.05 level (2-tailed).
**: Correlation is significant at the 0.01 level (2-tailed).

Table 3-2. Results of bivariate correlations

		E-M	E-C	E-Ta	E-Te	T-M	T-C	T-Ta	T-Te				
Gender	Pearson Correlation	-.070	-.088	-.025	.048	-.073	-.069	-.090	-.105				
	Sig. (2-tailed)	.466	.357	.791	.616	.445	.472	.348	.271				
	N	112	112	112	112	112	112	112	112				
Age	Pearson Correlation	-.082	-.105	.057	-.073	.012	.013	.084	.180				
	Sig. (2-tailed)	.389	.273	.550	.446	.897	.894	.381	.057				
	N	112	112	112	112	112	112	112	112				
Qualification	Pearson Correlation	-.164	-.101	.014	-.079	-.151	.039	-.013	.040				
	Sig. (2-tailed)	.083	.288	.887	.409	.111	.682	.889	.678				
	N	112	112	112	112	112	112	112	112				
Academic Background	Pearson Correlation	**.233***	-.020	.127	.089	.101	-.080	.029	.105				
	Sig. (2-tailed)	.013	.835	.181	.350	.291	.400	.758	.271				
	N	112	112	112	112	112	112	112	112				
Searching Skills	Pearson Correlation	.136	.015	-.091	-.072	.010	.053	.119	.054				
	Sig. (2-tailed)	.153	.877	.342	.449	.916	.578	.210	.573				
	N	112	112	112	112	112	112	112	112				
Experience with digital library	Pearson Correlation	-.102	-.040	-.127	-.061	-.026	**-.217***	-.050	-.117				
	Sig. (2-tailed)	.285	.675	.183	.525	.784	.022	.603	.218				
	N	112	112	112	112	112	112	112	112				

*: Correlation is significant at the 0.05 level (2-tailed).
**: Correlation is significant at the 0.01 level (2-tailed).

humanistic backgrounds when interacting with digital library. Experience with digital libraries is highly influenced and is an important factor in schema-training, planning, and transfer. Overall, gender, age, educational background, and experience with digital library are powerful factors in determining students' level of metacognitive skills while interacting with digital libraries.

As shown in Table 2, university students have the highest metacognitive skills in transfer component. This means that it helps students with experience in other fields to accurately grasp the types of information needed for learning tasks. Conversely, metacognitive skills are low in transfer-technology, indicating that they are reluctant to use what they learn from other tasks in their use of sources and techniques.

V. Discussion and Conclusion

The purpose of this study is to analyze the metacognition of digital library search behavior and provide a fundamental data for a user-centered design of online information retrieval system. We found a couple of significant aspects in this study as follows.

First, when searching for digital libraries, there is a strong correlation between demographics and metacognitive skills of university students. Four of the six demographic factors (i.e, gender, age, educational background, and digital library and experience) were found to have an important relationship with the metacognitive components.

Second, age seems to have been considered as another important factor when students use the metacognitive skill in searching behavior using digital libraries. Older students seemed to have ways to monitor and fix problems as well as help them understand the information they found on their own.

Third, academic background seems to be considered as an important factor. Engineering students have shown that they use techniques such as summaries to monitor their understanding while searching with digital libraries.

Forth, the experience of use of digital libraries seems to be the most important factor. Students with extensive digital library experience demonstrated the use of metacognitive skills in both main and sub-categories.

Fifth, university students show excellent performance in transfer of metacognitive skills while searching the digital library. This means that the majority of students considered how to maintain information after learning what they learned from various tasks that could be applied to how sources and technologies can be utilized.

In conclusion, although considering the limitation of the number of participants in this study and the characteristics of digital library searching behavior, it is impossible to see it as a representative sample of all students. In addition, the procedure for verifying the reliability and validity of the measurement tool has been omitted in this study. However, we hope that this result will serve as an opportunity to pay more attention to metacognition in future research in the field of user-centered design of digital library. And the implication of this study is that the use of metacognitive skills in ICT contributed to the creation of robust digital libraries, so interaction designers for digital libraries should consider not only demographic factors but also individual users' metacognition.

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