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Eighth graders' web searching strategies and outcomes: The role of task types, web experiences and epistemological beliefs

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Abstract

This study reported an investigation of eighth graders' (14-year-olds) web searching strategies and outcomes, and then analyzed their correlations with students' web experiences, epistemological beliefs, and the nature of searching tasks. Eighty-seven eighth graders were asked to fill out a questionnaire for probing epistemological beliefs (from positivist to constructivist-oriented views) and finished three different types of searching tasks. Their searching process was recorded by screen capture software and answers were reviewed by two expert teachers based on their accuracy, richness and soundness. Five quantitative indicators were used to assess students' searching strategies: number of keywords, visited pages, maximum depth of exploration, refinement of keyword, and number of words used in the first keyword. The main findings derived from this study suggested that, students with richer web experiences could find more correct answers in "close-ended" search tasks. In addition, students with better metacognitive skills such as keyword refinement tended to achieve more successful searching outcomes in such tasks. However, in "open-ended" tasks, where questions were less certain and answers were more elaborated, students who had more advanced epistemological beliefs, concurring with a constructivist view, had better searching outcomes in terms of their soundness and richness. This study has concluded that epistemological beliefs play an influential role in open-ended Internet learning environments.

Keywords: Web search; Epistemological beliefs; Web experiences; Searching strategy; Constructivism

1. Introduction

Currently, people's daily lives are greatly influenced by information technologies like computers and the web. According to Gulli and Signorini's (2005) estimation, in the mid-2005, there were more than 11.5 billion pages on indexable web. New webpages appear at the rate of 8% per week (Ntoulas, Cho, & Olston, 2004). However, the increasing number of webpage has also brought problems such as information overload,

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disorientation, and decreased information quality (Ahuja & Webster, 2001; Rockland, 2000). Although plentiful information can be accessed on the web, there is no guarantee to its validity and reliability in any way (Tsai, 2001). Therefore, in order to successfully find useful information on the web, users need to consider the usages of their searching strategies to generate better outcomes.

Web searching is a complicated cognitive skill. Therefore, the outcomes of web searching are influenced by a variety of factors. Rouet (2003) found that users' personal characteristics and the nature of the searching task were two main factors related to their searching strategies and outcomes. Users' practical experience on web searching also influenced their searching outcomes (Beaufils, 2000; Bilal, 2000; Fenichel, 1981; Guthrie, 1988; Kim, 2001; Navarro-Prieto, Scaife, & Rogers, 1999). Palmquist and Kim (2000) concluded that students' practical experiences on web searching played a more important role in their searching outcomes than their general experiences on using computer and the Internet. Users with less training on web searching needed more time to find information, tended to make more mistakes during the searching process, and had less ability to conduct successful searching on the web. Furthermore, because novices on web searching did not know how to employ searching strategies like experienced web searching users, they tended to browse the information and navigate the Internet or hypertext in a linear way (Hölscher & Strube, 2000; Qiu, 1993a).

The nature of searching task was another influential factor on users' web searching strategies and outcomes (Navarro-Prieto et al., 1999). Qiu (1993b) found that users had more analytical searching in "specific" "closed" tasks, while they conducted more browsing in tasks with "general" "open" answers. In addition, Bilal's (2000, 2001) and Kim and Allen's (2002) studies with students from different age groups all found that comparing to research-based ("open") tasks, students have higher percentage of success in fact-finding ("closed") tasks. However, still not much research explored how different factors, other than searching strategies, might contribute to searching outcomes of different tasks.

Recently, educators highlight the role of users' epistemological beliefs in web searching and web-based cognitive activities (Hofer, 2004; Tsai, 2004a). People's epistemological beliefs reflect their views about the nature of knowledge and knowing, and these views are found to be related to ways of learning or approaches to processing learning tasks (Hofer & Pintrich, 1997). Hofer (2004) and Tsai (2004a) have asserted that students' epistemological beliefs guide their cognitive as well as metacognitive activities in web environments. Learners with more constructivist-oriented epistemological beliefs tended to express more preferences to engage in metacognitive thinking in web environments (Tsai & Chuang, 2005). In addition, Whitmire (2003) found that students' epistemological beliefs had great influence on their decision-making process when they searched the web. Recent research revealed that college students who held less sophisticated epistemological beliefs were less likely to engage in the web-based discussion and communication activities (Braten & Stromso, 2006). Therefore, learners' epistemological beliefs should be considered as an important factor when studying their activities on the web.

Derived from existing studies as discussed above, a model about relevant factors on web searching outcomes is presented in Fig. 1. Because web searching is a series of cognitive activities, users' prior web experi-

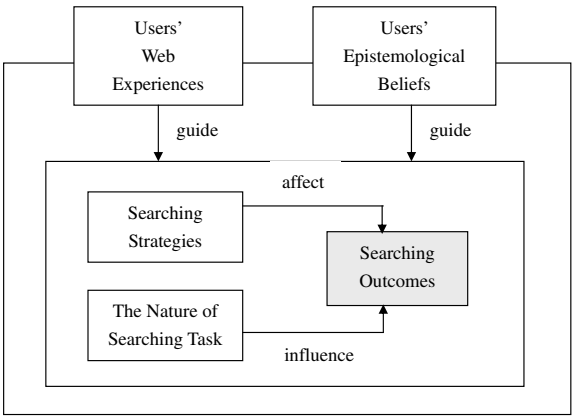

Fig. 1. A model of relevant factors on web searching outcomes.

ences and their epistemological beliefs are two fundamental factors affecting their searching strategies and understanding as well as interpretation about searching tasks at hands. These two factors, considered as users' personal characteristic variables in this study, are also related to searching outcomes. As well, the searching strategies and the nature of searching task are perceived as important factors related to the final searching outcomes. In Fig. 1, "searching outcomes" was highlighted as the ultimate goal for all related factors on web searching.

Although many of these factors on users' web searching outcomes have been studied from various perspectives by numerous scholars in previous studies (e.g. Kim, 2001; Rogers & Swan, 2004; Shenton & Dixon, 2004; Slone, 2003), there were some unique features of this study, which could complement the lack of existing research. First, this study considered users' epistemological beliefs as one of the fundamental factors that guided their web searching processes and outcomes. Still little research addressed this issue. Second, few studies were conducted to investigate how different factors, in addition to searching strategies, might contribute to searching outcomes of different types of tasks. Third, this study took all of the factors in Fig. 1 into account and discussed the correlations among them simultaneously. By examining the model in Fig. 1, researchers can acquire a better picture about each student's searching strategies and outcomes. Finally, this study chose eighth graders (14-year-olds) as research sample, while most of related studies undertaken in the past focused on higher education students (college or graduate students, e.g., Fiorina, Antonietti, Colombo, & Bartolomeo, 2007; Hofer, 2004; Kim & Allen, 2002; Whitmire, 2003). Although some previous research might consider similar age level of the participants of this study, they did not elaborate many factors related to students' searching outcomes to gain a better picture. As young learners have gradually become a major group of web users, a careful investigation on their web searching strategies and outcomes is quite necessary in contemporary stage. This research is particularly important in Taiwan, as the new educational policy from 1998 has asked that all school curricula in Taiwan need to develop students' abilities to "correctly, safely, and efficiently use technology to collect, analyze, evaluate, and apply information to enhance learning outcome and life quality" (Ministry of Education in Taiwan, 2003). However, there were still insufficient studies focusing on Taiwanese middle or junior high school students' abilities of web searching.

2. Research purposes

The purpose of this study was to investigate the roles of web experiences, epistemological beliefs, the nature of searching tasks on a group of Taiwan eighth graders' web searching strategies and searching outcomes. Based on literature review, we developed a conceptual model as our theoretical perspectives, shown in Fig. 1, and we adapted it to carry out this research. Therefore, this study was conducted to explore:

(1) The correlations among students' web experiences, epistemological beliefs, web searching strategies, and searching outcomes.
(2) The effects of different types of web searching tasks on students' searching outcomes, and how different factors may be related to students' searching outcomes of different types of tasks.

3. Methodology

3.1. Participants

The participants of this study included 49 male and 38 female students from a public junior high school at a big city in the middle part of Taiwan, and their socio-economic status was nearly above average. To a certain extent, these students can represent a majority of typical junior high school students in Taiwan. These students were randomly selected from four eighth-grade (around 14-year-olds) classes in the school. Because most of the participating students had computers ($n = 83$, 95%) and web connections ($n = 69$, 79%) at home, it was reasonable to assume that computers and the web were commonly distributed in families at big city in Taiwan. Furthermore, students' web usage experiences were also surveyed by using their self-reported online hours per week. That is, their web experience was represented by the hours they spent on the web in each week, similar to

that defined by Tsai (2001). Although 77% (67 students) of participating students self-reported that they, on average, used the web less than 10 hours per week, all students had computer courses since elementary schools, and many school courses required them to search information on the web for academic purposes.

3.2. Data collection and analysis

Participating students were asked to fill out a questionnaire and finished three searching tasks in their computer courses at school. The questionnaire was used to assess students' epistemological beliefs. For searching tasks (described later), students' information-searching processes were recorded by a screen capture software called *Camtasia Recorder*. All students were asked to use Yahoo! as the beginning search engine, but they could connect to any other search engines later. Time limitation for three searching tasks in total was 20 minutes.

3.3. Questionnaire about students' epistemological beliefs

Chan and Sachs' (2001) questionnaire, called Epistemological Belief Scale (EBS), was used to assess participating students' epistemological beliefs. This questionnaire included nine questions and this study used six of them that had better internal consistency with a reliability coefficient (KR20) of 0.56. The reliability of original Chan and Sachs' questionnaire was 0.52. Therefore, the coefficient 0.56 of these six questions, though not very high, was considered as satisfactory. Although there were other questionnaires showing better psychometrical properties than EBS (e.g., Duell & Schommer-Aikins, 2001), it was chosen because of several reasons. First, EBS was developed in an eastern context, it may be more suitable for the participants in this study. Second, Chan and Sachs designed this questionnaire to examine the epistemological beliefs of middle school students who were at similar age groups with the participants of this study. Finally, unlike most questionnaires that contained couple dozens of questions (e.g., Duell & Schommer-Aikins, 2001), EBS only included nine questions originally, which was both easy and appropriate to be used with students at eighth grade. This questionnaire was also translated and validated by another study for assessing Taiwanese high school students' epistemological beliefs (Tsai & Chuang, 2005).

Each questionnaire item included three options. Among the three options of each question, only one can reflect students' constructivist epistemological beliefs. If students choose this constructivist option, they were scored 1 point. Otherwise, they obtained 0 point. Students with higher EBS scores indicated that their epistemological beliefs were more sophisticated, constructivist-oriented. In other words, students who got higher EBS scores suggested that they were more likely to construct their own knowledge based on prior knowledge and experiences. It also showed that they had a more proactive attitude toward studying and learning. On the other hand, students with lower EBS scores tended to conceptualize knowledge and learning as received by simple accumulation, oriented to a positivist view about knowledge. The following was a sample question from the questionnaire:

When you are learning something new, the most important thing to do is:

(a) to figure out how it fits or does not fit with what you already know;
(b) to get all of the facts you can about it;
(c) to write down what you have learned so you will not forget it.

For this question, students who chose the constructivist-oriented option, (a), would obtain one point. However, students were scored 0 point for choosing option, (b) or (c).

3.4. Searching tasks

In this study, three searching tasks were assigned to the participating students. They included both "open-ended" and "close-ended" questions. The searching topic, nuclear energy, was chosen with considerations of students' prior knowledge and living experiences. Although before participating in this study, students did not

experience formal instruction about nuclear energy, there was a fierce debate about "nuclear energy" in Taiwan. Therefore, this searching topic was a life question without prior school knowledge. The tasks were designed to be able to be finished in 20 minutes. Three searching tasks were:

(1) What are the currently used energy resources in Taiwan?
(2) What are the advantages and disadvantages of nuclear energy?
(3) Among all of the energy resources, what do you think is the better energy resource? Why?

For the first question, there were seven standardized answers (i.e., Taiwan uses seven energy resources). Each answer got 1.5 points. If students wrote down all of the correct answers, they got 10 points for this task. However, if students wrote any answer that was not included in the seven standardized answers, 0.5 point would be deducted from their total score of this task. For the second question, there were particular answers but allowing students to think more openly. Any reasonable answer got 1 point, and any unreasonable answer would be deducted 0.5 point from the total score of this task. And for the third question, students needed to search web resources, analyze and critically evaluate web materials, and put personal thoughts into answers to complete that task. Since the question asked students "what do you think" and "why", it may require their high-level cognitive skills such as reasoning and decision-making abilities such as doing judgment or strategies (Henri, 1992). This question also asks the students to make self-reflections upon their own perspectives, thus possibly related to their metacognitive capacities. There were no standardized answers for the last question. The students' responses of this question were rated on their soundness, richness and organization from 0 to 10 points. In sum, each searching task was scored 0–10, and the total score of the three searching tasks were 0–30.

Each student's answers were reviewed by two experts. Both experts were science teachers in junior high schools and had more than ten years of teaching experiences. The final score was the average of the two experts' giving scores. However, if the difference between two experts' giving score on any searching task was more than 3 points, the two experts would discuss to decide the final score of the particular question.

3.5. The analysis of students' web searching strategies

The whole process of students' web navigation was recorded by a screen capture software called *Camtasia Recorder*. The recorded data were further analyzed through five quantitative indicators. These indicators were modified from those used by Lin and Tsai (2007) in analyzing students' web searching strategies:

1. Number of keywords: indicating the level of variations of searching.
2. Number of visited pages: indicating the variations in webpage browsing.
3. Maximum depth of exploration: showing the depth of exploration when students browsed through the webpages. Each student's navigational path of web searching was also recoded by the computer.
4. Refinement of keyword: represented by the average number of words per keyword. The shorter the keywords, the better the refinement skills.
5. Number of words used in the first keyword: showing users' skills of applying existing knowledge and experiences to identify primary ideas when they are assigned a new searching task. Students with better metacognitive skills would presumably use shorter first keyword because they have better abilities on filtering information.

Although these indicators mainly focused on the keyword formulation process of web searching, "number of visited pages" and "maximum depth of exploration" were also recorded by the computer in order to investigate users' navigational sequence during the search. According to previous literatures, formulating effective searching query was difficult to most web users (Hirsh, 1999; Lancaster, 1968; Spink, Bateman, & Jansen, 1999). However, the abilities of keyword identification and refinement were vital to web searching success (Park & Kim, 2007). Weideman and Strumpfer (2004) also found that the number of keywords used to search also had strong effect on searching outcomes. So, in this study, we particularly highlighted students' strategies of keyword selection and refinement while searching web information.

4. Results

4.1. The analysis of searching outcomes

4.1.1. Students' web searching strategies and web searching outcomes

As described previously, the whole processes of students' web searching were recorded by the computer, and their searching strategies and behaviors were analyzed by five quantitative indicators. Table 1 showed statistical data about the five quantitative indicators of students' searching strategies and their searching outcomes on three assigned tasks.

The differences between minimum and maximum in all five indicators were obvious. As for students' web searching outcomes, the average performance of task one (5.62) was the highest. It was probably because task one was the simplest question among three searching tasks.

4.2. Correlations among students' web experiences, epistemological beliefs, web searching strategies, and outcomes

The correlations between students' web searching strategies, searching outcomes, web experiences, and epistemological beliefs are presented in Table 2.

Among the five indicators of students' web searching strategies, "visited pages" was significantly correlated with "number of keywords" ($r = 0.45$, $p < 0.01$) and "maximum depth of exploration" ($r = 0.54$, $p < 0.01$). It was possibly because the more keywords students used to search, the more lists of related pages they would get, and therefore, had more opportunities to explore webpages deeply. However, "visited pages" was negatively correlated with "refinement of keyword" ($r = -0.23$, $p < 0.05$) and "number of words used in the first keyword" ($r = -0.22$, $p < 0.05$). It was reasonable that students who used less number of words in keywords indicated better ability in keyword refinement. The better refined keywords students used to search the web, the more chances that they would get more related webpages to visit later. Furthermore, the most significantly positive correlation was found between "refinement of keyword" and "number of words used in the first keyword" ($r = 0.80$). As defined previously, the "number of words used in the first keyword" can show students' metacognitive abilities in the web searching process. It is plausible that the better the ability of keyword refinement, the better the ability of metacognition.

As for the correlations of the five searching strategies across the three task performances, only "refinement of keyword" and "number of words used in first keyword" showed significant correlations with "task one performance", "task two performance," and "total performance." In addition, these significant correlation coefficients were all negative. It meant that using more refined keyword or less number of words in first keyword seemed to lead to better performances in task one, two, and total performance. As discussed before, both "refinement of keyword" and "number of words used in first keyword" were abilities related to metacognition. Therefore, it was possible to assume that the students with better abilities of refining keyword or metacognition would perform better in task one and task two, which were oriented to "close-ended" search tasks. Other

Table 1
Descriptive statistics of students' web searching strategies and web searching outcomes across different tasks

	Minimum	Maximum	Mean	SD
Number of keywords (Strategy 1)	1	14	4.61	2.71
Visited pages (Strategy 2)	2	39	12.23	8.37
Maximum depth of exploration (Strategy 3)	1	5	1.87	1.09
Refinement of keyword (Strategy 4)	2	14	7.88	3.43
Number of words used in the first keyword (Strategy 5)	2	14	8.87	5.00
Task one performance (Outcome 1)	0	10	5.62	2.64
Task two performance (Outcome 2)	0	9	3.94	3.34
Task three performance (Outcome 3)	0	9.5	4.55	3.12
Total performance (Outcome)	0	27.5	14.11	6.46

Table 2
Correlation among students' web strategies, searching outcomes, web experiences, and epistemological beliefs

	Number of keywords (Strategy 1)	Visited pages (Strategy 2)	Maximum depth of exploration (Strategy 3)	Refinement of keyword (Strategy 4)	Number of words used in the first keyword (Strategy 5)	Task one performance (Outcome 1)	Task two performance (Outcome 2)	Task three performance (Outcome 3)	Total performance (Outcome)	Web experiences	Epistemological beliefs
Number of keywords (Strategy 1)	1.00	.45**	.06	−.12	−.08	−.00	.13	−.18	−.02	.05	.02
Visited pages (Strategy 2)		1.00	.54**	−.23*	−.22*	.01	.01	−.17	−.07	.07	−.26*
Maximum depth of exploration (Strategy 3)			1.00	−.25*	−.33**	.09	.10	−.10	.04	.07	−.22*
Refinement of keyword (Strategy 4)				1.00	.80**	−.22*	−.27*	−.05	−.25*	−.08	.04
Number of words used in the first keyword (Strategy 5)					1.00	−.26*	−.25*	−.02	−.24*	−.07	.12
Task one performance (Outcome 1)						1.00	.48**	.16	.74**	.31**	.06
Task two performance (Outcome 2)							1.00	.13	.78**	.22**	.34**
Task three performance (Outcome 3)								1.00	.62**	−.13	.22*
Total performance (Outcome)									1.00	.18	.30**
Web experiences										1.00	−.04
Epistemological beliefs											1.00

* $p < 0.05$.
** $p < 0.01$.

strategies might not be significant factors for predicting students' searching performances. This result also responded to the focus of this study on including keyword formulation as influential searching strategies to students' web searching outcomes.

Table 2 also shows that students' web experiences were not related to the usage of any searching strategy. However, web experiences had significantly positive correlation with the searching outcomes of the first task ($r = 0.31$, $p < 0.01$), and second tasks ($r = 0.22$, $p < 0.01$). It indicated that students with richer web experiences tended to perform better in the first and second tasks. Because both of task one and task two were oriented to "close-ended" type of tasks (especially task one), it was plausible to assume that students tended to achieve better searching outcomes (finding correct answers) if they had more prior web experiences. In contrast to the first two tasks, the third task was "open-ended" task. It required higher-level thinking during the process of searching. Therefore, students' web experiences did not show significant correlation with their searching outcomes for this specific task.

In addition, students' epistemological beliefs were significantly negatively correlated with the "visited pages" and "maximum depth of exploration." These results suggested that students who had more constructivist-oriented epistemological beliefs, tended to visit less webpages and have less depth of exploration. It was hypothesized that constructivist-oriented students might have better judgments on verifying the correctness and relevancy of visited webpages than the other students. Their epistemological beliefs might help them effectively determine if the webpage contained the information they needed. This concurred with the perspective proposed by Tsai (2004b) that epistemological beliefs could help learners develop better standards of evaluating online information. Furthermore, for epistemological beliefs, significant correlation was revealed with task two ($r = 0.34$, $p < 0.01$), task three ($r = 0.22$, $p < 0.05$), and total performance ($r = 0.30$, $p < 0.01$). This suggested that students having constructivist-oriented epistemological beliefs were more likely to achieve better searching outcomes in less "close-ended" and "open-ended" tasks. Based on the results in Table 2, students with constructivist-oriented epistemological beliefs tended to have better outcomes in open-ended task, but they tended to navigate less pages and in less depth. So, it was suggested that their constructivist-oriented epistemological beliefs may have helped them to carefully filter information and effectively complete the tasks (especially open-ended ones), and eventually achieve better outcomes.

4.3. Regression models for predicting search performance of different tasks

This study finally used students' web experiences, epistemological beliefs, and searching strategies as independent factors, through stepwise methods, to build a series of regression models of predicting students' searching outcomes for each task and total performance cross three tasks, presented in Table 3. By comparing the regression models, this study explored the effects of task types on students' searching outcomes.

The regression models revealed the following findings. In "close-ended" tasks, students' "web experiences" was the most primary factor that predicted their searching outcomes. Task one in this study was "close-ended" task with fixed answer. In the regression models, students' "web experiences" and "number of words used in the first keyword" were the only two significant factors, proposing that the major predicting factors for this type of task were users' web experiences and metacognitive abilities. Similar results can be found in the regression model of task two performance. Task two may be a "close-ended" one as well, but it allowed more flexible answer than task one. In its final regression model, students' "epistemological beliefs", "number of words used in the first keyword" and "web experience" were included as three significant variables. Students with more constructivist-oriented epistemological beliefs, more web usage experiences, and better metacognitive abilities (using fewer words in the first keyword) tended to have better performance in task two.

More importantly, in an "open-ended" task like task three, students who had stronger constructivist-oriented epistemological beliefs had better performance scores. That is, among all studied factors, students' "epistemological beliefs" was the primary and the *only* variable that could significantly predict their searching outcomes in open-ended task. The role of epistemological beliefs in searching outcomes became obvious in open-ended task. Finally, the regression model for students' total performance across three tasks, "epistemological beliefs" was the first significant factor to be selected into the model, and "number of words used in the first keyword" was the second selected factor. Therefore, we concluded that the major predicting factors for students' searching outcomes in general included students' epistemological beliefs and metacognitive abilities.

Table 3
Regression models for predicting performances of different tasks

Outcome	Model	Predictors	*B*	Std. error	*β*	Sign.	R
Task one performance (Outcome 1)	1	(constant)	4.70	.41	.00		
		Web experience	.40	.14	.31	.00	.31
	2	(constant)	5.84	.63		.00	
		Web experience	.39	.14	.29	.01	
		Number of words used in the first keyword	−.12	.05	−.23	.02	.39
Task two performance (Outcome 2)	1	(constant)	.64	1.06		.55	
		Epistemological beliefs	.90	.27	.34	.00	.34
	2	(constant)	2.21	1.12		.07	
		Epistemological beliefs	.99	.26	.37	.00	
		Number of words used in the first keyword	−.19	.07	−.29	.00	.44
	3	(constant)	1.07	1.17		.37	
		Epistemological beliefs	1.00	.26	.38	.00	
		Number of words used in the first keyword	−.18	.06	−.28	.01	
		Web experience	.37	.16	.22	.03	.49
Task three performance (Outcome 3)	1	(constant)	2.53	1.03		.02	
		Epistemological beliefs	.55	.26	.22	.04	.22
Total performance	1	(constant)	8.31	2.08		.00	
		Epistemological beliefs	1.56	.53	.30	.00	.30
	2	(constant)	10.39	2.20		.00	
		Epistemological beliefs	1.73	.52	.33	.00	
		Number of words used in the first keyword	−.36	.13	−.28	.01	.41

*$p < 0.05$, **$p < 0.01$.

5. Conclusions and suggestions

This study reported an investigation of eighth graders' web searching strategies and outcomes, and then analyzed their correlations with students' web experiences, epistemological beliefs, and the nature of searching tasks. The main findings derived from this study suggested that, for closed-ended tasks where answers were more fixed, students with richer web experiences could attain better searching outcomes than those who had less web experiences. Therefore, by increasing students' web experiences can effectively improve their searching outcomes in this type of searching task. In addition, students with better abilities of keyword refinement tended to achieve more successful searching outcomes in close-oriented searching tasks. However, in "open-ended" tasks, where questions that were less certain and answers were more elaborated, students should involve complicated higher-level thinking and decision-making in the searching process. Students' cognitive loads were increased as well because of the difficulty in verifying precise searching keywords. In such task, students who had more advanced epistemological beliefs, concurring with a constructivist view, could achieve better searching outcomes.

Moreover, this study found that students with more advanced, constructivist-oriented, epistemological beliefs showed some evidence about purposeful thinking skills. For instance, although they navigated less webpages and in less depth during the searching process, students with constructivist-oriented epistemological beliefs tended to have better outcomes in open-ended tasks. It was possibly because their epistemological beliefs help them to purposefully filter information and then effectively complete the tasks. This kind of skill was very helpful to students in verifying, judging information, and to utilize appropriate searching strategies. As Whitmire's (2003) study indicated, during the web searching process, information-searchers' epistemological beliefs were related to the decisions they made about searching strategies and information verification. Tsai (2004b) and Wu and Tsai (2005) also believed that users' advanced epistemological beliefs could guide them develop sophisticated standards of evaluating online information and strategies for web navigation.

However, as shown in previous research (Bilal, 2000; Bilal & Kirby, 2002; Hsieh-Yee, 2001; Weyer, 1982), it seemed difficult for students to conduct efficient web searching through interpreting search questions and generating appropriate keywords. Many students in this study used natural language-like question as their

searching keyword. They simply modified the searching task question and used it as their searching keyword. It was probably because of students' lack of metacognitive abilities or familiarities of web searching engines. Similar results can be found in other studies on this domain as well (Fidel et al., 1999; Spink, Wolfram, Jansen, & Saracevic, 2001). Because "refinement of keyword" and "number of words used in first keyword" were the only two searching strategy indictors that showed significant correlations with students' searching outcomes in close-ended oriented task, it was possible to conclude that students' abilities of keyword formulation were influential factors among searching strategies to their task performances on the web. Therefore, how to enhance students' metacognitive abilities of keyword refinement should be one of the major goals for today's educators. Rogers and Swan (2004) suggested that before conducting web searching, teachers could develop activities such as concept map of words to help students to apply vocabulary in related contexts.

This study also found that even with advanced technological tools, still many eighth graders in this study could not finish all three searching tasks in assigned 20 minutes. This result showed that although the new curriculum policy in Taiwan addressed the importance of students' abilities of using information technologies, many students in this study did not have enough basic skills in web searching. They were not familiar with related computer operations, software functions, and the web itself. It may reveal the problem that current curriculum emphasized too much on students' trainings of computer skills, but not on their practical experiences of applying information-searching skills into various learning activities. Lack of experience and practical training were the possible obstacles that prevented them from completing assigned searching tasks. Moreover, because this study used students' self-reported hours spent online per week as the indicator of their web experiences, it might be possible for the eighth graders to reflect mainly to their "messenger time" spent on the web. Future study is suggested to use different approaches to investigate students' prior web experiences, or define "web experiences" more precisely when asking students how much time spent on web.

Like many studies in new developed subject areas, the sample size of this study was rather small (e.g., Bilal, 2000, 2001; Lin & Tsai, 2007; Fiorina et al., 2007). However, the study results were successfully pointed out significant correlations among students' web experiences, epistemological beliefs, searching strategies, searching outcomes, and different types of searching tasks. Other possible influential factors that were not considered in this study may include students' intelligence and academic outcomes. In order to further investigate users' web searching behaviors, future study is suggested to have more participants, focus on different grades, and consider different influential factors. The time users spent on completing searching tasks can be another useful indicator in analyzing their web searching behaviors. Instead of using screen capture software, future study is also suggested to use advanced system such as Meta-Analyzer (Hwang, Tsai, Tsai, & Tseng, 2008), an internet-based environment combining research tools and instructional tools, to record and analyze students' web searching activities. The web itself is a fundamentally open environment to all users. Through the process of information-searching on the web, students can improve their ability of metacognition and skill of web searching. This study found that users' epistemological beliefs played a primarily influential role to the searching outcomes of "open-ended" tasks. It is clear that much of web searching is oriented to open-ended, and the significance of users' epistemological beliefs should be highlighted. This perspective is consistent with that proposed by Hofer (2004) and Tsai (2001, 2004a), strengthening the importance of epistemological beliefs in web-based learning context. However, due to the limitation of the use of the questionnaire in this study, categorizing students' epistemological beliefs from positivist-oriented to constructivist-oriented (Chan & Sachs, 2001), future studies are encouraged to use some instruments of representing learners' epistemological beliefs as multifactorial (e.g., Duell & Schommer-Aikins, 2001) to explore the role of epistemological beliefs on web-based learning further. Also, promoting students' epistemological beliefs can provide valuable assistance to students in web searching activities, shaping a critical issue for future research.

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References

Ahuja, J. S., & Webster, J. (2001). Perceived disorientation: An examination of a new measure to assess web design effectiveness. *Interacting with Computers, 14*, 15–29.

Beaufils, A. (2000). Tools and strategies for searching in a hypermedia environment. *Journal of Computer Assisted Learning, 16*, 114–124.

Bilal, D. (2000). Children's use of the Yahooligans! Web search engine. I. Cognitive, Physical and affective behaviors on fact-based tasks. *Journal of the American Society for Information Science, 51*, 646–665.

Bilal, D. (2001). Children's use of the Yahooligans! Web search engine. II. Cognitive, Physical and affective behaviors on fact-based tasks. *Journal of the American Society for Information Science, 52*, 118–137.

Bilal, D., & Kirby, J. (2002). Differences and similarities in information seeking: children and adults as web users. *Information Processing and Management, 38*, 649–670.

Braten, I., & Stromso, H. I. (2006). Epistemological beliefs, interest, and gender as predictors of internet-based learning activities. *Computers in Human Behavior, 22*, 1027–1042.

Chan, C. K. K., & Sachs, J. (2001). Beliefs about learning in children's understanding of science texts. *Contemporary Educational Psychology, 26*, 192–210.

Duell, O. K., & Schommer-Aikins, M. (2001). Measures of people's beliefs about knowledge and learning. *Educational Psychology Review, 13*, 419–449.

Fenichel, C. H. (1981). Online searching measures that discriminate among users with different types of experiences. *Journal of the American Society for Information Science, 32*, 23–32.

Fidel, R., Daviez, R. K., Douglass, M. H., Holder, J. K., Hopkins, C. J., Kushner, E. J., et al. (1999). A visit to the information mall: web searching behavior of high school students. *Journal of the American Society for Information Science, 50*, 24–37.

Fiorina, L., Antonietti, A., Colombo, B., & Bartolomeo, A. (2007). Thinking style, browsing primes and hypermedia navigation. *Computers and Education, 49*(3), 916–941.

Gulli, A., & Signorini, A. (2005). The indexable web is more than 11.5 billion pages. In *Proceedings of the 14th international conference on World Wide Web, 902–903, Chiba Japan*, 10–14 May 2005.

Guthrie, J. T. (1988). Locating information in documents: Examination of a cognitive model. *Reading Research Quarterly, 23*, 178–199.

Henri, F. (1992). Computer conferencing and content analysis. In A. R. Kaye (Ed.), *Collaborative learning through computer conferencing* (pp. 117–136). New York: Springer.

Hirsh, S. (1999). Children's relevance criteria and information seeking on electronic resources. *Journal of the American Society for Information Science, 50*(14), 1265–1283.

Hofer, B. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist, 39*(1), 43–55.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*, 88–140.

Hölscher, C., & Strube, G. (2000). Web search behavior of internet experts and newbies. *Computer Network, 33*, 337–346.

Hsieh-Yee, I. (2001). Research on web search behavior. *Library and Information Science Research, 23*, 167–185.

Hwang, G.-J., Tsai, P.-S., Tsai, C.-C., & Tseng, J. C.-R. (2008). A novel approach for assisting teachers in analyzing student web-searching behaviors. *Computers and Education, 51*(2), 926–938.

Kim, K. S. (2001). Information seeking on the web: Effects of user and task variables. *Library and Information Science Research, 23*, 233–255.

Kim, K. S., & Allen, B. (2002). Cognitive and task influences on web searching behavior. *Journal of the American Society for Information Science, 53*(2), 109–119.

Lancaster, F. W. (1968). *Information retrieval systems: characteristics, testing and evaluation*. New York: Wiley.

Lin, C.-C., & Tsai, C.-C. (2007). A "navigation flow map" method of representing students' searching behaviors and strategies on the Web. *CyberPsychology and Behavior, 10*, 689–695.

Navarro-Prieto, R., Scaife, M., & Rogers, Y. (1999). Cognitive strategies in web searching. Retrieved March 1, 2005. http://zing.ncsl.nist.gov/hfweb/proceedings/navarro-prieto/index.html.

Ntoulas, A., Cho, J., & Olston, C. (2004). What's new on the web? The evolution of the web from a search engine perspective. In *Proceedings of the 13th international World Wide Web Conference* (pp. 1–12). New York.

Palmquist, R. A., & Kim, K. S. (2000). Cognitive style and online database search experience as predictors of web search performance. *Journal of the American Society for Information Science, 51*, 558–566.

Park, Y., & Kim, B. S. (2007). Web search using dynamic keyword suggestion. *International Journal of Computers and Applications, 29*(1), 1365–1708.

Qiu, L. (1993a). Markov models of search state patterns in a hypertext information retrieval system. *Journal of the American Society for Information Science, 44*, 413–427.

Qiu, L. (1993b). Analytical searching vs. browsing in hypertext information retrieval systems. *Journal of the American Society for Information Science, 18*, 1–13.

Rockland, R. H. (2000). Reducing the information overload: A method on helping students research engineering topics using the Internet. *IEEE Transactions on Education, 43*, 420–425.

Rogers, D., & Swan, K. (2004). Self-regulated learning and internet searching. *Teachers College Record, 106*(9), 1804–1824.

Rouet, J. F. (2003). What was I looking for? The influence of task specificity and prior knowledge on students' search strategies in hypertext. *Interacting with Computers, 15*, 409–428.

Shenton, A. K., & Dixon, P. (2004). Issues arising from youngsters' information-seeking behavior. *Library and Information Science Research, 26*, 177–200.

Slone, D. J. (2003). Internet search approaches: The influence of age, search goals, and experience. *Library and Information Science Research, 25*, 403–418.

Spink, A., Bateman, J., & Jansen, B. J. (1999). Searching the web: A survey of excite users. *Internet Research: Electronic Networking Applications and Policy, 9*(2), 117.

Spink, A., Wolfram, D., Jansen, B. J., & Saracevic, T. (2001). Searching the web: The public and their queries. *Journal of the American Society for Information Science and Technology, 52*(3), 226–334.

Tsai, C.-C. (2001). A review and discussion of epistemological commitments, metacognition, and critical thinking with suggestions on their enhancement in Internet-assisted chemistry classrooms. *Journal of Chemical Education, 78*, 970–974.

Tsai, C.-C. (2004a). Beyond cognitive and metacognitive tools: The use of the Internet as an "epistemological" tool for instruction. *British Journal of Educational Technology, 35*, 525–536.

Tsai, C.-C. (2004b). Information commitments in web-based learning environments. *Innovations in Education and Teaching International, 41*, 105–112.

Tsai, C.-C., & Chuang, S. C. (2005). The correlation between epistemological beliefs and preferences toward internet-based learning environments. *British Journal of Educational Technology, 36*(1), 97–100.

Weideman, M., & Strumpfer, C. (2004). The effect of search engine keyword choice and demographic features on internet searching success. *Information Technology and Libraries, 23*(2), 58–66.

Weyer, S. K. (1982). The design of a dynamic book for information search. *International Journal of Man–Machine Studies, 17*, 87–107.

Whitmire, E. (2003). Epistemological beliefs and the information-seeking behavior of undergraduates. *Library and Information Science Research, 25*, 127–142.

Wu, Y.-T., & Tsai, C.-C. (2005). Information commitments: Evaluative standards and information searching strategies in web-based learning environments. *Journal of Computer Assisted Learning, 21*, 374–385.