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Abstract

Purpose – Semantic technologies are a potential approach to enhancing the use of the web of knowledge. An experiment was conducted to investigate the roles of two semantic techniques, namely concept recommendation and mind maps, for females and males This paper aims to document this research.

Design/methodology/approach – The study compared the searching behaviours and perceptions of searching strategies in the search environment with techniques to reveal the gender difference in the use of semantic technologies. The study further investigated how the techniques influenced female and male students' searching experiences by comparing their searching behaviours and strategies in two different environments, one developed with the semantic technologies and one without.

Findings – Although the techniques were helpful for both female and male students in improving their perceptions of searching strategies, there were gender differences in sense of disorientation, problem solving and searching patterns. In particular, the techniques facilitated females to search for information beyond similarity holes, but did not demonstrate such an effect on males. However, they supported males to organize information for better use.

Research limitations/implications – The study is only a small-scale investigation. Further studies need to be conducted with a larger sample to obtain robust evidence.

Originality/value – In this paper, the effects of semantic technologies are evaluated from the perspectives of education and the human factor, rather than only in terms of technical performance.

Keywords Information searches, Men, Women, Technology, Semantics, Information seeking, Semantic technologies, Gender difference, Web of knowledge

Paper type Research paper

Introduction

In recent years, researchers and educators have been addressing the importance of the web of knowledge for learning (Liu *et al.*, 2010; Savolainen and Kari, 2006; Tsai, 2009; Tu *et al.*, 2008). The main reason is that the rich information on the web can be used as a knowledge resource, or as an alternative channel for solving problems (Walraven *et al.*, 2009). Examples of the web of knowledge are Wikipedia, Google scholar and the ISI web of knowledge. Such webs of knowledge may play an important role in education. For instance, users can develop their problem solving ability when they search for and use the information in these webs to complete a learning task (Yang and Chang, 2009). However, the web of knowledge includes a variety of types of

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information. It is rather complicated and challenging for users to search on the web (Debowski, 2001; Tsai and Tsai, 2003; Tu *et al.*, 2008).

Previous studies have indicated that learning in such an open-ended internet environment may be affected by multiple factors such as technology self-efficacy (Durndell and Haag, 2002; Peng *et al.*, 2006; Tsai and Tsai, 2003) and metacognition (Tsai, 2009; Tsai and Tsai, 2003; Tu *et al.*, 2008). For example, users who do not have enough knowledge about searching do not have effective searching skills to learn from the web of knowledge (Debowski, 2001; Savolainen and Kari, 2006), while users with low metacognition skills cannot use appropriate keywords to acquire information. Consequently, it is necessary to investigate how to facilitate different users to enhance their learning from the web of knowledge based on their specific needs.

Currently, several systems are available to assist users in exploring the web of knowledge. For instance, some database providers, such as the ISI web of knowledge and Google scholar, provide a query function so that users can efficiently search for information in their database. However, users might not know how to use appropriate keywords for querying because of a lack of sufficient prior knowledge (Savolainen and Kari, 2006). Moreover, users may not know how to search on the web of knowledge as well as experts do. This is because they may lack self-awareness of what they need (Dias *et al.*, 1999), and often face the problem of disorientation (Conklin, 1989; Ignacio Madrid *et al.*, 2009; Tsai, 2009). Hence, there is an imperative need to provide learning support to help users apply effective search strategies to search for information on the web of knowledge.

Semantic technology can be a potential solution to the issues above. Such technology encodes the comprehensive meanings and structures of complex information objects so that users may understand the information objects before detailed reading (Berners-Lee and Fischetti, 1999). This is achieved by retrieving, linking and organising the semantic information of the information objects (Berners-Lee *et al.*, 2001). The semantic technologies can facilitate users to explore on the web with an organised knowledge structure, and users may thus expand their knowledge domain (Liu *et al.*, 2010).

With the aforementioned advantages, researchers have started to apply semantic technologies in educational contexts in recent years. For example, Blanco-Fernández *et al.* (2008), Hsu (2009) and Yu *et al.* (2007) have proposed methodologies to recommend learning materials based on the semantic information of the materials and users' learning profiles. Although semantic technologies may be helpful in enhancing learning, most of the literature focuses on the technical evaluation, for instance the recall and precision, of such technology (Blanco-Fernández *et al.*, 2008; Ciravegna *et al.*, 2004; Doan *et al.*, 2003). To better use the technology in an educational context, it is necessary to investigate how semantic technologies may affect users' searching activities and strategies while learning from the web.

A previous study has investigated how such technologies may facilitate students to learn with the web of knowledge (Tseng *et al.*, 2011). However, many researchers have shown that gender factors play a crucial role in web searching (Chen and Macredie, 2010; Durndell and Haag, 2002; Large *et al.*, 2002; Peng *et al.*, 2006; Roy and Chi, 2003; Tsai, 2009; Tsai and Tsai, 2003). For instance, males tend to browse more pages than females to perform a search task (Schacter *et al.*, 1998). Moreover, the searching strategies that males and females apply to explore the web are profoundly different

(Large *et al.*, 2002; Roy and Chi, 2003). Therefore, this paper presents a follow-up study investigating how gender difference plays a role in the use of semantic technologies to this end. In addition, it is worth understanding how female and male users may react to the semantic technologies when they are exploring the web of knowledge.

More specifically, this study investigates how and to what extent gender difference influences users' explorative experiences with the semantic technologies by answering the following research questions:

- Do female and male users differ in their search behaviours when searching with the semantic technologies?
- Do female and male users differ in their information searching strategies when searching with the semantic technologies?
- How do semantic technologies influence females' information searching behaviours and strategies?
- How do semantic technologies influence males' information searching behaviours and strategies?

Related work

Problems associated with learning from the web of knowledge

Previous studies have indicated many problems that users may encounter when learning from the web of knowledge. A critical problem is information overload (Ahuja and Webster, 2001; Rockland, 2000; Tsai, 2009; Tu *et al.*, 2008). More specifically, users have problems effectively evaluating over-abundant web information due to insufficient searching knowledge (Savolainen and Kari, 2006; Scheiter and Gerjets, 2007; Tu *et al.*, 2008). Moreover, a lack of self-efficacy on the Internet may also impede the use of web knowledge in learning. For instance, Tsai and Tsai (2003) suggested that students with low Internet self-efficacy cannot apply high-order information searching strategies. Peng *et al.* (2006) also further indicated that such students generally demonstrate low motivation when learning from the web of knowledge.

Numerous studies have also shown the problem of disorientation during learning with the web (Jenkins *et al.*, 2003; Tsai, 2009; Tsai and Tsai, 2003; Tu *et al.*, 2008). In other words, users often do not know what to do or where to find useful information because they do not have a sophisticated knowledge structure to guide their searching (Ahuja and Webster, 2001; Dias *et al.*, 1999). Another cause of such disorientation is the inadequate searching strategies and skills that users are able to apply. More specifically, users often repeatedly apply only the keywords they know to search the web of knowledge (Tu *et al.*, 2008). Consequently, their search is limited to a constraint scope and hence they cannot expand their knowledge through the search. It is thus necessary to help users to identify prominent keywords to search for useful information on the web of knowledge (Savolainen and Kari, 2006; Tu *et al.*, 2008).

Enhancing the web of knowledge with semantic technologies

The previous studies reveal that exploring the web of knowledge is a complex learning process. Semantic technology may be a potential approach to addressing this issue. This is because semantic technologies enable information to be interconnected by encoding conceptual meanings from assorted information objects (Berners-Lee and Fischetti, 1999; Yu *et al.*, 2007). For instance, keyword extraction techniques such as

TF-IDF and Taxonomy based disambiguation (Dill *et al.*, 2003) are often used to extract conceptual meaning from information objects (Ciravegna *et al.*, 2004). In these techniques, it is computers that extract the conceptual meaning from the web. However, some researchers have advocated that users can better understand the meaning of information objects (Wu *et al.*, 2006). Therefore, a social tagging mechanism (Shepitsen *et al.*, 2008) in which users identify the conceptual meaning of information objects has been used to promote the usage of the web of knowledge.

Although the aforementioned techniques can help extract the conceptual meaning of the web of knowledge, it is established on a single information object only. The relationship between information objects is still not clear. Consequently, users can only acquire isolated information without having a complete picture of the searched web of knowledge. Some studies have thus utilized data mining approaches to link the separate information. For example, the clustering technique has been used to calculate the hierarchical relationship among information objects (Han and Yan, 2009; Maedche and Zacharias, 2002). Besides, the association rule technique has been applied to discover the relationship between information objects (Chen and Chen, 2007). As such, users can obtain a conceptual structure of the web of knowledge (Géry and Haddad, 1999; Qin *et al.*, 2004).

Due to the above features, the semantic technology is regarded as a potentially effective approach to helping users learn on the web (Chyan *et al.*, 2007; Koper, 2004; Mäkelä, 2005; Tiropanis *et al.*, 2009), because a structural framework of the web of knowledge can thus be formed to reduce the complexity of the learning process. For instance, in the study by Koper (2004), he integrated conceptual information with a row of information objects to represent the structure of the web of knowledge. By doing so, users could effectively draw out the relationships among the information objects on the web of knowledge. However, the evaluation of the aforementioned studies focuses on the technical performance of these techniques. For example, the precision and recall of the search results are critical criteria for evaluating the performance of systems (Blanco-Fernández *et al.*, 2008; Ciravegna *et al.*, 2004; Yu *et al.*, 2007). Little research has so far been carried out to investigate how and to what extent semantic technologies impact learning from the web of knowledge.

Gender difference in web searching

To better understand the effect of semantic technologies, the study presented in this paper explores how these technologies influence different users in their learning with the web of knowledge. In particular, this study focuses on the influence of gender difference. This is because gender difference is a crucial factor that may influence searching behaviour. For instance, in the studies by Roy and Chi (2003) and Roy *et al.* (2003), they found that males demonstrate more productive searching behaviour than females. More specifically, males are more active, formulate more queries, and browse more web pages than females (Large *et al.*, 2002). However, there is still no clear understanding of how gender difference with semantic technologies influences searching performance. Therefore, it is worth investigating how semantic technologies may influence females and males' searching behaviours.

Many reasons may contribute to the above differences between females and males. One of the possible reasons is the gender difference in attitudes toward computers and the internet. In an early study by Schacter *et al.* (1998), they found that males use the web of knowledge more frequently than females do. This may be due to the fact that females are, on the whole, less interested than males in using computers (Bandura, 1997; Comber and Colley, 1997; Shashaani, 1997). Moreover, males perceive a higher level of self-efficacy (Durndell and Haag, 2002; Peng *et al.*, 2006), less computer anxiety (Durndell and Thomson, 1997; Jackson *et al.*, 2001) and more positive attitudes (Peng *et al.*, 2006; Roy and Chi, 2003) than females when it comes to using the internet. These findings may account for why females and males differ in their searching behaviours. Due to the difference between females and males, a further study to understand gender perceptions of the use of semantic technologies on the web of knowledge is clearly necessary.

The searching strategies that females and males apply to searching the web may be a potential factor influencing search performance. Many studies (Jenkins *et al.*, 2003; Klöckner *et al.*, 2004; Large *et al.*, 2002; Roy and Chi, 2003) have found that males take a breadth-first approach while females take a depth-first approach. More specifically, males tend to search for information objects broadly, and spend less time on each object. Conversely, females generally delve into a specific search direction, and spend more time on individual information objects. Such a strategic difference between females and males may also influence the effect of semantic technologies on searching the web of knowledge.

Due to the above gender difference, it is hypothesised that semantic technologies will have different impacts on females and males. To achieve a better understanding of how semantic technologies can be used to support learning with the web, an empirical study was conducted to investigate how females and males search for information while they are using semantic technologies. It is hoped that through this study we can understand the role of gender difference in the use of semantic technologies.

Study methodology

Research design and procedures

The participants of this study were chosen randomly from a graduate institute in northern Taiwan. The participants were 30 graduate students whose ages ranged from 23-25. Of the participants, 15 were females while the others were males. Because of the gender balance, these participants can help us contrast male and female students' searching behaviours and perceptions during the experiment.

The participants took part in two exploratory activities in different environments. Both of the activities lasted 90 minutes, during which all participants had to search for information on the web of knowledge to answer a question related to technology-enhanced learning domains. The questions were open-ended. For instance, one of the questions was "What are the pros and cons of game-based learning, and how can game-based learning be applied in classrooms?" Due to the open-endedness of the questions, the students had to compare and integrate different information resources to obtain a global understanding of the questions.

The main purpose of this study is to understand how females and males behave in learning environments with and without semantic technologies. Therefore, the students were instructed to use two interfaces to perform the two learning activities (shown as Figure 1). In one of the activities, the students used only the keyword search environment (referred to hereafter as the keyword-based environment) which is commonly supported by many commercially available databases such as Google

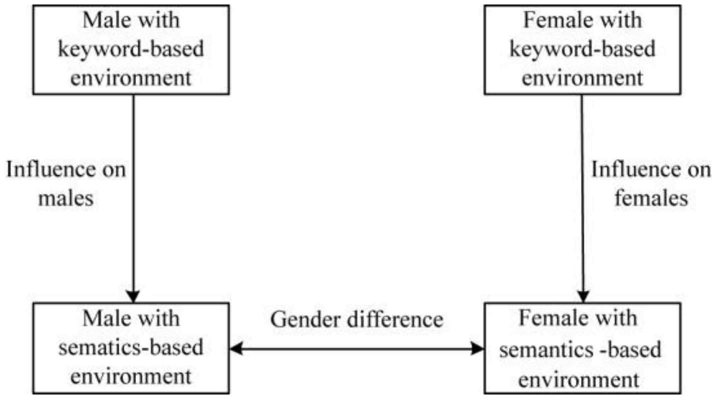

Figure 1.
The analysis framework of this study

scholar, Science direct, and the ISI web of knowledge. In the other activity, the learning from the web took place in an environment with semantic technologies (referred to as the semantics-based environment) designed to help search for information on the web. By using such a research approach, the study can gain a better understanding of the gender difference in using semantic technologies as well as the effect of semantic technologies on females and males.

Instruments – the keyword-based environment

This study selected the ISI web of knowledge as the main knowledge base to support learning. This is because it is one of the most widely used databases for academic purposes in the main subject domains. Such a web of knowledge can support the students to experience authentic searching practice in an educational context. The students were provided with two environments to use the web of knowledge. One is the keyword-based environment which is provided by the ISI web of knowledge. The other is the semantics-based environment developed by a previous study (Liu *et al.*, 2010).

The keyword-based environment was used in the first activity. The environment provides the following search functions:

- Keywords search: the environment supports basic query functions such as searching by keyword, topic, author, publication name and time.
- Logical search: the environment supports logical expressions (e.g. AND or OR) that allow users to specify compound search conditions.
- Refine results: the environment supports re-queries based on previously searched results.
- Search results directory: the environment provides a directory for users to manage their search results. The directory is a plain pool where users can log the information objects they are interested in for further use.

The participants used the keyword-based environment to perform the search. After the first learning activity, they participated in the second one, as described below.

Instruments – the semantics-based environment

In the second activity, the students performed the learning task in the semantics-based environment. Because of the large number of information objects in the database, the environment applied several semantic techniques to support the students to understand the relationship among information objects from their conceptual meaning. More specifically, the environment allows the students to search for information objects based on their conceptual affinity relationships. To achieve this goal, this semantics-based environment applied TF-IDF (Salton *et al.*, 1975) and association rule techniques (Agrawal *et al.*, 1993) to process the more than 50,000 papers from the journals of education, learning and technology which were selected.

The two techniques were applied to process a total of 50,786 papers from 118 journals in the categories of Educational Research and Development, Special Education, and Ergonomics in the ISI web of knowledge. More specifically, the TF-IDF technique was used to extract keywords from these papers. A total of 152,823 keywords were identified by the TF-IDF. Because these keywords represent the frequently-used terms in the technology-enhanced learning domain, they can help students understand the conceptual meaning of the information objects.

Based on the identified keywords, the association rule mining techniques were used to discover the relationship between information objects. More specifically, the mining technique calculated the frequency of the co-occurrence of two keywords in an information object. The frequency reflects the level of correlation of the two keywords. In other words, if two terms frequently appear together in papers as keywords, those two terms should be considered as closely related. With such relationships between keywords, the semantics-based environment provides the following conceptual supports for the students:

- Keywords search: the environment allows the students to search for papers by keyword.
- Keywords suggestions: The environment suggests relevant keywords on the students' request based on the relationship of keywords identified by the above techniques. More specifically, the environment provides the keywords that are considered as closely related to a stated keyword according to the association rules. Thus, the students may expand their search direction.
- Relationship identification: the environment provides a joint search function with which the students can confirm whether two keywords are related. This is done by examining whether the association rule techniques consider the two keywords to be associated. If they are associated, the environment further recommends papers that contain the two keywords to the students.

The above supports were provided in a mind map interface because mind maps are an effective interface for managing and organizing complex information objects (Buzan, 1994; Liu *et al.*, 2005). Figure 2 shows an example of how one student used the semantics-based environment to search for information on the web of knowledge.

The white ovals represent the concepts that the student queried himself, while the green ovals represent the associative concepts that were generated based on his self-identified keywords from the concept association knowledge database. The notebook icon represents the search results dictionary, and the arrows show which keywords are associated with each query. The yellow post-it note icon indicates that

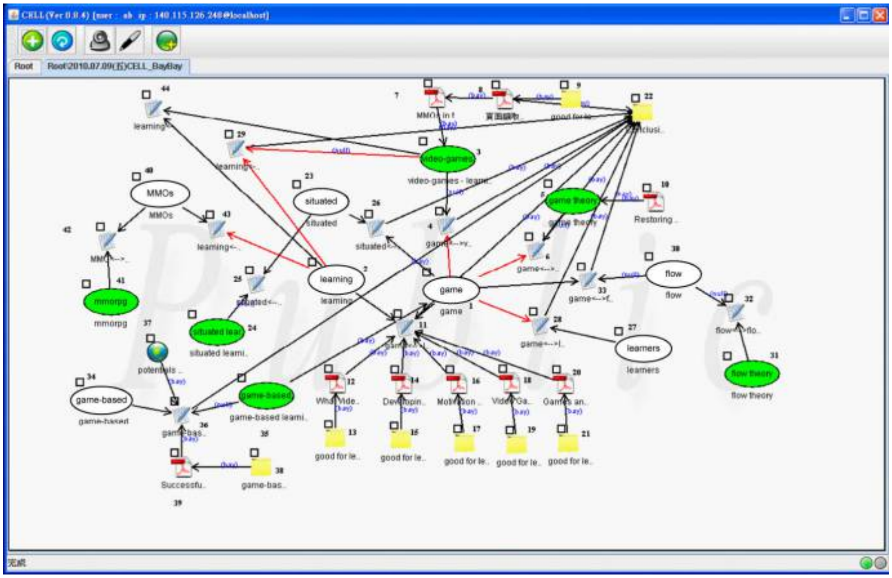

Figure 2.
An example of searching with semantics technologies

the student wrote down personal ideas and comments, or recorded useful information from the papers.

At the beginning, the student used "game" (in a white oval) as a keyword to search for information. Then, the semantics-based environment recommended a list of relevant keywords related to "game". The student selected "video-game learning" as a keyword and the environment provided a list of papers related to the two keywords. During the search activity, the student also tried to identify the relationship between the "game" and "learning" keywords. Therefore, he applied the relationship identification function to determine whether the two keywords were related. Based on his request, the semantics-based environment suggested a list of papers related to the two keywords. The whole process was shown and logged in the mind map. With the support of the environment, the student not only received the keyword suggestions to expand his search direction, but could also understand the relationship between the information objects.

Instruments – questionnaire

One of the goals of this study is to understand the information searching strategies applied by students in the two environments. Therefore, the Online Information Searching Strategies Inventory (OISSI) proposed by Tsai (2009) was implemented to obtain the students' perceptions of the application of the searching strategies. This inventory has good framework criteria as it presents good reliability (0.91). In addition, the total explained variance was 68 per cent as an instrument to evaluate the applications of different levels of searching strategies. Therefore, this inventory also shows good validity.

The question items of the OISSI were slightly adapted to fit the context of this study. The questionnaire consists of seven aspect strategies, including control, disorientation, trial and error, problem solving, purposeful thinking, selecting main ideas and evaluation. The questionnaire included a total of 25 items, which were presented using a six-point Likert scale (ranging from 1, "strongly disagree" to 6, "strongly agree"). The main purposes of the aspects and question items of the adapted OISSI are presented in the Appendix (Table AI). A principle components method factor analysis was applied to examine the structural validity and reliability of the instrument. The results showed that the total reliability Cronbach's alpha value was 0.90, and the total explained variance was 71 per cent, which was adequate for explanation. In addition, the objects of this study were graduate students, which is consistent with the objects of the OISSI questionnaire. Hence, the OISSI questionnaire exhibited good reliability and validity and was suitable to evaluate the students' information searching strategies in this study.

Instruments – on-screen behaviours

The on-screen video screens of how the students used the two environments were recorded using the Camtasia software. In order to discover how the females and males searched for information in the two environments, the on-screen videos were analysed to obtain more comprehensive behavioural attributes that show how the students searched for information in the two environments. A total of six behavioural attributes were identified; these attributes are considered as important indicators of successful online searching (Tu *et al.*, 2008), and are described in detail as follows:

- Frequency of keyword searching: The number of times keyword searches were applied by the students to search for papers in the environment.
- Number of keywords: The number of keywords indicates the number of distinct keywords that a student used to search for information. It should be noted that the students could use specific keywords to search for information. However, some keywords did not extend the scope of the search task. Instead, these keywords fall into a specific keyword cluster in which they are all equivalent. Hence, all keywords used by the students were pre-processed based on some simple rules. For instance, a plural noun form keyword was considered identical to its singular form. For instance, "video game" and "video games" were identified as the same keyword. In addition, a different notation of a keyword was also considered as identical to its general notation. For instance, the term "1 to 1 learning" and "1:1 learning" were considered equivalent to the general notation "one-to-one learning".
- Frequency of logical searching: This attribute reveals the number of times that a student used logical expressions to orchestrate multiple search criteria to query documents.
- Frequency of repeated search: The student may repeat using a keyword to search for information. This frequency reveals the number of times that the students performed such repeated searches.
- Number of papers downloaded: This attribute may reveal the quantity of information that a student considered useful during the information seeking activity.
- Number of papers cited in reports: This attribute may display the valid impact of the information seeking activity on learning as the students may have used only a small portion of the papers they found to complete their reports.

The above student searching behaviours were identified in the two environments. The behavioural attributes in the two environments were compared to reveal the impact of the semantics-based environment on females and males.

Data analysis

The above behaviour attributes and OISSI feedback were analysed to answer the research questions of this study. This study compares the females and males' searching behaviours and their OISSI feedback using the Mann-Whitney U test to understand the gender difference in the use of the semantic technologies. The Mann-Whitney U test was applied because the sample size was small. In addition, the study further investigates how the semantic technologies influenced the females and males' searching behaviours and strategies. Therefore, females and males' searching behaviours and their OISSI feedback in the keyword-based environment were compared to those in the semantics-based environment. It is hoped that such a comparison can obtain a better understanding of how the semantic technologies influence females and males' searching behaviours and strategies.

Results of search behaviours

This section presents the results of the students' searching behaviours and perceptions in the semantics-based environment. In particular, we focus on how gender difference plays a role in the students' behaviours and perceptions. In addition, male and female students' searching behaviours and perceptions in the two environments are described independently so that the effect of the semantics-based environment for females and males can be clearly displayed.

Gender difference in searching with semantic technologies

Table I shows the difference in the information searching behaviours between the female and male students in the semantics-based environment. The results reveal that there is no significant difference between the female and male students with regard to six information-searching behaviours. Although the male students downloaded more papers than the females students in the semantics-based environment, the difference was only marginally significant ($U = 70$, $p = 0.07$). From observing the on-screen videos, we found that the males tended to read the papers in detail after gathering all

	Gender	Mean	Median	U	p
Frequency of keyword searching	Male	11.93	11.00	93.00	0.417
	Female	13.13	13.00		
Number of keywords	Male	4.40	4.00	92.00	0.393
	Female	5.67	4.00		
Frequency of logical search	Male	3.73	4.00	103.00	0.689
	Female	4.00	4.00		
Frequency of repeated search	Male	0.67	0.00	105.00	0.718
	Female	0.80	0.00		
Number of papers downloaded	Male	5.47	5.00	70.00	0.071
	Female	4.20	4.00		
Number of papers cited	Male	4.13	4.00	81.00	0.179
	Female	3.20	3.00		

Table I. The searching behaviours of females and males in the semantics-based environment the information, while the females preferred to read a paper carefully as soon as it was found to be useful. In other types of information searching behaviours, the female and male students searched for information using a similar pattern when they used the semantics-based environment.

Table II illustrates the results of the OISSI questionnaire of the female and male students. The results show that overall the male students did not perceive a significantly higher level of searching strategies than the female students. However, the male students perceived a higher level of problem solving strategies than the female students. The differences approach the significant level. Such results suggest that the female students may not be as skilful as the male students in solving the problems that occur while using the semantic technologies. In addition, even aided with the semantic technologies, the female students still perceived a relatively higher level of disorientation than the male students.

Table II. The searching strategies of females and males in the semantics-based environment

	Gender	Mean	Median	U	p
Control	Male	4.81	4.75	90.50	0.358
	Female	4.63	4.50		
Disorientation[a]	Male	5.10	5.00	66.00	0.051
	Female	4.68	4.50		
Trial and error	Male	4.78	5.00	92.00	0.386
	Female	4.56	4.67		
Problem solving	Male	4.71	5.00	70.50	0.077
	Female	4.27	4.33		
Purposeful thinking	Male	4.80	5.00	85.00	0.249
	Female	4.57	4.75		
Select main ideas	Male	5.04	5.00	103.50	0.705
	Female	4.96	5.00		
Evaluation	Male	4.58	4.50	106.00	0.784
	Female	4.43	4.75		

Notes: [a] Scores have been reversed; $^{*}p < 0.05$

Table III. Males' searching behaviours in the keyword-based and semantics-based environments

	Environment	Mean	Median	Z	p
Frequency of keyword searching	Keyword-based	8.67	8.00	−1.48	0.138
	Semantics-based	11.93	11.00		
Number of keywords	Keyword-based	5.47	5.00	−0.84	0.401
	Semantics-based	4.40	4.00		
Frequency of logical search	Keyword-based	4.33	4.00	−0.153	0.878
	Semantics-based	3.73	4.00		
Frequency of repeated search	Keyword-based	1.00	1.00	−1.30	0.194
	Semantics-based	0.67	0.00		
Number of papers downloaded	Keyword-based	4.47	5.00	−1.34	0.180
	Semantics-based	5.47	4.00		
Number of papers cited	Keyword-based	2.00	2.00	−2.78	0.005**
	Semantics-based	4.13	4.00		

Note: $^{*}p < 0.01$

The influence of semantic technologies on males and females' searching behaviours

Table III reveals the difference in the male students' searching behaviours between the keyword-based and the semantics-based environments. The only significant difference in their behaviours between the two environments was in citing papers. In other words, the semantics-based environment facilitated the male students to cite more useful information in their reports than they did in the keyword-based environment. From the screen videos, we found that most of the male students repeatedly opened their downloaded papers and browsed back and forth between the papers. However, they seldom organised the results of their searches. Among the 15 male students, only five copied some text from their search results to a text editor such as Microsoft Word or PowerPoint. In other words, they did not often organize their search results to show the salient relationship between the different information objects they found. On the contrary, in the semantics-based environment, the male students often wrote down personal comments on post-it note nodes and identified the important concepts of the papers they downloaded. Based on these concepts, they further drew relationships between the different papers and the post-it notes. Hence, they could cite more useful information, as they could understand the organisation of the information they found in the semantics-based environment. Such results indicate that the male students relied heavily on the mind map to integrate and reflect on the information they found on the web of knowledge.

Table IV shows the difference in the female students' searching behaviours in the two environments. The result reveals that the influence of semantic technologies on the female students' searching behaviours differs from that on the male students. The female students applied keyword searching more frequently and used more keywords when they searched with the semantic technologies. The difference approached the significant level ($Z = -1.94$, $p = 0.053$ and $Z = -1.77$, $p = 0.077$). Moreover, the female students applied significantly fewer logical searches in the semantics-based environment than they did in the keyword-based environment ($z = -0.194$, $p < 0.05$). From the screen videos, we found that the female students often only used a very few keywords and applied logical searches to combine these keywords to search for information in the keyword-based environment. In other words, they could only search

	Environment	Mean	Median	Z	p
Frequency of keyword searching	Keyword-based	9.07	8.00	− 1.94	0.053
	Semantics-based	13.13	13.00		
Number of keywords	Keyword-based	3.20	2.00	− 1.77	0.077
	Semantics-based	5.67	4.00		
Frequency of logical search	Keyword-based	7.87	6.00	− 2.32	0.020*
	Semantics-based	4.00	4.00		
Frequency of repeated search	Keyword-based	1.93	0.00	− 0.98	0.325
	Semantics-based	0.80	0.00		
Number of papers downloaded	Keyword-based	4.60	4.00	− 0.46	0.645
	Semantics-based	4.20	4.00		
Number of papers cited	Keyword-based	2.67	3.00	− 1.27	0.204
	Semantics-based	3.20	3.00		

Note: * $p < 0.05$

Table IV. Females' searching behaviours in the keyword-based and semantics-based environments for information with a very limited set of keywords. On the contrary, when searching with semantic technologies, they could obtain keyword suggestions, based on which they could perform keyword searches to obtain further information. Such a result suggests that keyword suggestions may be an effective approach for assisting female students to search for information on the web.

The influence of semantic technologies on males and females' searching strategies

Table V shows the results of the male students' perceptions of the two environments. The result reveals that overall, the males perceived a higher level of searching strategies with the semantic technologies. The males perceived a significantly higher level of control in the semantics-based environment than they did in the keyword-based environment ($z = -2.91$, $p < 0.001$). Moreover, they felt a lower level of disorientation while searching with the semantic technologies ($z = -1.96$, $p = 0.05$). The semantics-based environment also significantly facilitated them to conduct purposeful searching ($z = -3.30$, $p < 0.001$), select the main ideas from the searched results ($z = -3.33$, $p < 0.001$), and evaluate the web of knowledge ($z = -3.19, p < 0.001$). However, no significant differences were found in terms of trial and error and problem solving. Such a result suggests that the semantic technologies demonstrated a positive effect on the males' searching strategies.

Table VI displays the results of the female students' perceptions in the two environments. The results indicate that the females' responses on the OISSI were similar to those of the males. That is, they also perceived a higher level of search strategies with the semantic technologies, including control, disorientation, purposeful thinking, selecting the main ideas, and evaluation. However, the females reflected that they perceived a significantly higher level of trial and error strategies with the semantic technologies ($z = -2.25$, $p < 0.05$) than they did in the keyword-based environment. The male students did not perceive such an improvement.

	Environment	Mean	Median	Z	p
Control	Keyword-based	3.92	3.75	−2.91	0.004**
	Semantics-based	4.81	4.75		
Disorientation[a]	Keyword-based	4.55	4.75	−1.96	0.050*
	Semantics-based	5.10	5.00		
Trial and error	Keyword-based	4.38	4.33	−1.58	0.113
	Semantics-based	4.78	5.00		
Problem solving	Keyword-based	4.40	4.33	−1.544	0.123
	Semantics-based	4.71	5.00		
Purposeful thinking	Keyword-based	2.70	3.00	−3.30	0.001**
	Semantics-based	4.80	5.00		
Select main ideas	Keyword-based	3.51	3.67	−3.33	0.001**
	Semantics-based	5.04	5.00		
Evaluation	Keyword-based	3.10	3.50	−3.19	0.001**
	Semantics-based	4.58	4.50		

Notes: [a] Scores have been reversed; * $p < 0.05$ ** $p < 0.01$

Table V.
Males' information searching strategies in the keyword-based and semantics-based environments

Table VI. Females' information searching strategies in the keyword-based and semantics-based environments

	Environment	Mean	Median	Z	p
Control	Keyword-based	3.67	3.75	−3.30	0.001**
	Semantics-based	4.63	4.50		
Disorientation[a]	Keyword-based	3.80	3.75	−2.20	0.028*
	Semantics-based	4.68	4.50		
Trial and error	Keyword-based	3.93	4.00	−2.25	0.025*
	Semantics-based	4.56	4.67		
Problem solving	Keyword-based	4.02	4.33	−0.699	0.504
	Semantics-based	4.27	4.33		
Purposeful thinking	Keyword-based	3.00	3.00	−3.24	0.001**
	Semantics-based	4.57	4.75		
Select main ideas	Keyword-based	3.29	3.33	−3.41	0.001**
	Semantics-based	4.96	5.00		
Evaluation	Keyword-based	2.88	3.00	−3.239	0.001**
	Semantics-based	4.43	4.75		

Notes: [a] Scores have been reversed; $^{*}p < 0.05$; $^{**}p < 0.01$

Discussion of findings and implications

Gender difference in searching with the semantic technologies

This study found that the females and males exhibited different behaviours and perceptions when searching with the semantic technologies in terms of three aspects, namely disorientation, problem solving, and the number of papers downloaded. Regarding the disorientation aspect, previous studies have found that females have a higher level of disorientation in the keyword-based environment than males (Chen and Macredie, 2010; Ford and Miller, 1996; Ford *et al.*, 2001; Leong and Hawamdeh, 1999). This study also found that the female students still perceived a higher level of disorientation than the male students, even though they were facilitated with the semantic technologies. However, the semantic technologies can facilitate both female

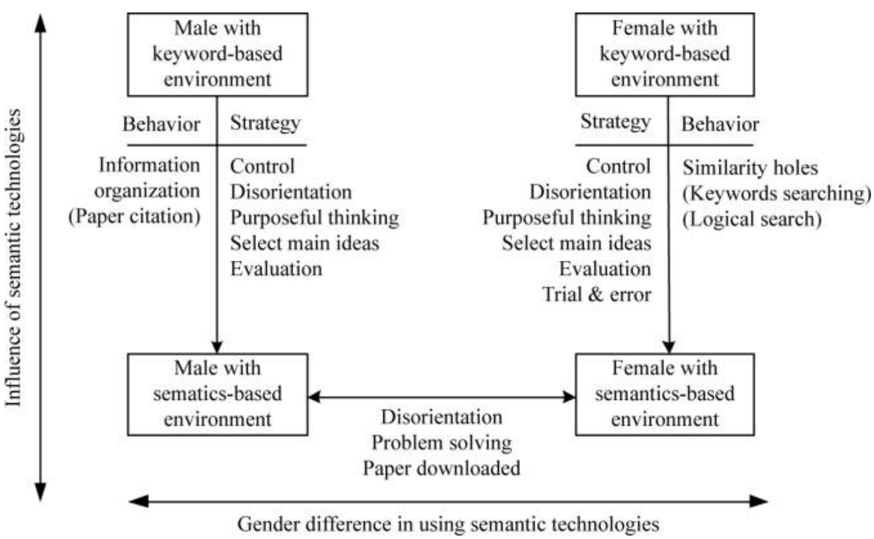

Figure 3. The model of searching with semantic technologies for female and male students

and males students to reduce their sense of disorientation (Tables V and IV). This result may reveal that gender difference does not particularly influence the effect of the technologies on reducing disorientation. The semantic technologies demonstrated positive effects for both male and female students. Figure 3 depicts the model of searching with semantic technologies for female and male students.

Regarding the problem solving aspect, according to the findings of previous studies (Large *et al.*, 2002; Roy and Chi, 2003; Tsai, 2009), the searching strategies applied by females to overcome search difficulties are not as effective as those applied by males. Similar results were found in this study. More specifically, it was found that the female students perceived a lower level of problem solving strategies when they were using the semantic technologies. This may be due to the gender difference in searching experiences (Li and Kirkup, 2007). Since males tend to be more experienced searchers (Shashaani, 1997; Roy and Chi, 2003), male students have more confidence and sophisticated searching skills to overcome difficulties than female students. Although the semantic technologies provided functional supports, the students still had to know how to use these supports to adapt their strategies to resolve the problems which occurred while searching. As a result, such technologies did not influence the gender difference in terms of problem solving.

Regarding the number of papers downloaded, this study found that the male students collected more papers than the female students. In other words, they preferred to gather more information. Such a preference may be due to the different search patterns adopted by females and males. Previous studies have indicated that males tend to take a breadth-first approach while females take a depth-first approach (Jenkins *et al.*, 2003; Klöckner *et al.*, 2004; Large *et al.*, 2002; Roy and Chi, 2003). In other words, males tend to search for information objects broadly, and spend limited time exploring a specific direction. On the contrary, females tend to delve into a specific search direction, and may spend more time on certain information objects. The finding of this study is consistent with the gender difference indicated by these studies in that the males tended to collect as broad a range of information as possible, while the females preferred to explore the information they found before they searched for further information.

The influence of semantic technologies on females and males' searching strategies

The study further discovered the influence of semantic technologies on searching strategies for females and males. The results exhibited that the semantic technologies were helpful for both female and male students in the aspects of control, disorientation, purposeful thinking, selecting main ideas, and evaluation. However, the semantic technologies only enhanced the females' trial and error strategy, while it did not influence the males' application of the trial and error strategy. In other words, the female students perceived a higher level of trial and error strategies when searching with semantic technologies than they did in the keyword-based environment. This may be because females tend to take a depth-first approach to searching for information and thus often search within a single search thread (Jenkins *et al.*, 2003; Klöckner *et al.*, 2004; Large *et al.*, 2002; Roy and Chi, 2003). As a result, they could not identify other keywords to extend their search and, thus, tended to only apply logical searches within a limited set of keywords when the current search thread did not work. On the contrary, when searching with semantic technologies, the females could obtain keyword suggestions if the current search thread was not successful. Based on the keywords suggested, they could initiate another search thread and, thus, perceived a higher level of trial and error strategy when searching with the semantic technologies.

The influence of semantic technologies on females and males' searching behaviours

The results of this study reveal that the semantic technologies enhanced female and male students' search for information in different ways. Regarding the female students, the semantic technologies not only facilitated them to apply more keywords to search for information, but also reduced the frequency of logical searches. This phenomenon may be related to the females' searching patterns. More specifically, the females tended to apply logical searches with a limited set of keywords (Large *et al.*, 2002; Roy and Chi, 2003). Such a searching pattern easily results in the problem of similarity holes. The problem occurs when searchers cannot search for information beyond what they already know (Liu *et al.*, 2010; McNee *et al.*, 2006). As the female students only applied logical searches to search for information within a limited set of keywords, they could not obtain information beyond the similarity hole. With the aid of keyword suggestions, the female students could query with distinct keywords, which the students might not know, to broaden their search directions. As a result, the female students used more keywords but fewer logical searches to search on the web of knowledge with the semantic technologies.

Regarding the male students, it is found in our study that they cited more papers when searching with the semantic technologies than they did in the keyword-based environment. In the keyword-based environment, they did not organise the search results in a particularly systematic manner. A previous study by Liu *et al.* (2010) indicated that mind maps are a helpful tool to assist students in organising information during searches to show the salient relationships between different information. This may explain why the male students cited more references in their reports when they were using a mind map as the search interface. More specifically, with the support of mind maps, they could not only extract prominent concepts from the information objects, but could also organize these concepts in a graphical presentation. Consequently, they cited more references when searching in the semantics-based environment.

Implications

The findings of this study suggest that the semantic technologies may be applied to help females and males search on the web. The findings of this study support the theory that the semantic technologies can facilitate both female and male students to apply higher level searching strategies in many aspects. Educators may apply keyword suggestions and mind maps to improve the searching experience in other educational contexts. In particular, this study found that the keyword suggestions can help the female students to apply trial and error strategies. Such a finding echoes the claim by Belkin (2000) and Savolainen and Kari (2006) indicating that one of the critical difficulties facing students is their inability to specify appropriate keywords and to search beyond similarity holes. Such a difficulty is particularly critical for females. Therefore, such results reflect that there is a need to provide facilities to help female students identify new search directions. Educators may need to provide female students with important keywords when they are trapped in similarity holes.

Regarding male students, the findings of this study suggest that there is a need to support them in enhancing the application and integration of information during search activities. It is suggested that mind maps are a good tool for addressing this issue.

Although semantic technologies could help both female and male students in searching on the web, the female students still perceived a higher level of disorientation and a lower level of problem solving strategies than the male students. These findings indicate that females may need other supports to help them resolve these problems. In addition, this study also found that female and male students applied different searching patterns. Researchers may need to be aware of such differences in gender preferences when applying web searching in educational contexts. For instance, researchers may investigate how such a difference may play a role in collaborative learning where heterogeneous features among group members are necessary to achieve better learning objectives (Johnson and Johnson, 1994).

Limitations

The results of this study demonstrate that semantic technologies may help females and males in their searching experience in different ways. However, the semantic technologies applied in this study are based on content-based information retrieval techniques. The concept associations were extracted by TF-IDF and association rule techniques, that is, the associations were not evaluated by human experts. It would be interesting to investigate whether the students may react to the semantic technologies differently when human-based techniques, such as collaborative filtering and social tagging, are used. However, this study is only a small-scale investigation. Further studies need to be conducted with a larger sample to obtain robust evidence. For instance, the study did not consider students' prior knowledge of the exploration topic. Students' searching behaviours and strategies may be influenced by prior knowledge. For instance, students with high prior knowledge may have searched with more specific keywords than those with low prior knowledge, thus influencing the findings of this study. In a similar vein, the findings of this study cannot be over-generalised to searchers of other ages because the participants in this study were graduate students. These students have more sophisticated search skills than those of a lower level.

Conclusions

Educators have addressed the prominent impact of the web of knowledge on learning. As semantic technologies may provide semantic information of the web, there is a need to gain a better understanding of how such technologies may influence students' searching experiences. To achieve this goal, this study conducted an empirical experiment to investigate the gender difference in searching with semantic technologies. The study found that when females and males use semantic technologies in searching, they differ in three aspects, namely disorientation, problem solving and searching patterns. In addition, the semantic technologies helped females and males in their searching in different ways. Semantic technologies are helpful for both females and males in the searching strategies of control, disorientation, purposeful thinking, selecting main ideas, and evaluation. Such technologies may further enhance females' trial and error strategies. Regarding searching behaviours, semantic technologies facilitate females to search beyond similarity holes. For males, such technologies can support them to organize information for better use.

This study used computers to extract semantic information to support information searching. It would be interesting to see what results would be generated by using folksonomies (Mathes, 2004). For instance, it would be worth investigating how females and males may learn with the social tags provided by Internet users. Moreover, the results of searching behaviours were analysed using statistical methods. Further analysis based on data mining, such as behavioural pattern analysis (Liu *et al.*, 2011), may be useful to identify the potential learning patterns associated with the semantic technologies. Gathering information on these issues through further work will help clarify the findings of this study.

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Appendix

Aspect	Purpose	Examples of questions
Control	To identify the perceived level of control in the use of searching applications	I know how to utilize advanced-search functions provided by the searching application I know how to extend my search to know other related works I know how to refine my search based on current search results I can easily manage the search results
Disorientation	To identify the perceived level of disorientation during the learning activity	I do not know what to do when I search for information with the searching application I always feel lost while searching for information with the searching application I always feel nervous when I search for information with the searching application I do not know how to start my searching when I search with the searching application
Trial and error	To identify the perceived level of skills for trying different approaches	I try other searching strategies when I cannot find enough information I try other keywords when my search is not successful I use different searching strategies and keywords to find useful information when I search with the searching application
Problem solving strategy	To identify the perceived level of problem solving approaches to overcome problems during the learning activity	I do my best to resolve any problems which occur when I search for information with the searching application I usually give up searching when I come up with unsolved problems I think of some resolutions when I am frustrated with searching problems
Purposeful thinking	To identify the perceived level of self-monitoring during the learning activity	Sometimes, I stop and think about what information is still lacking with the aid of the searching application I keep on reminding myself of the purpose of searching online with the aid of the searching application I usually make sure of the goals before starting my online searching with the aid of the searching application I think of how to utilize the searched information with the aid of the searching application

(*continued*)

Table AI. The main purposes and questions of the questionnaire

Aspect	Purpose	Examples of questions
Selecting main ideas	To identify the perceived level of skills for identifying the key concepts of the information	I can select effective keywords to search for information when I use the searching application I can catch the major concepts and relations between the search results given by the searching application I can select the main ideas provided in the search results given by the searching application
Evaluation	To identify the perceived level of skills for judging and organizing information	I keep on evaluating the relationships among the information given by the searching application I compare information that I retrieve during the search with the searching application I think of how to present and organize the data that I have searched from the web with the aid of the searching application I decide if the information provided in a web site is worth referencing with the aid of the searching application

Table AI.

Source: Adapted from Tsai (2009)

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