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Learning by Searching: A Learning Environment that Provides Searching and Analysis Facilities for Supporting Trend Analysis Activities

Chengjiu Yin[1], Han-Yu Sung[2], Gwo-Jen Hwang[3*], Sachio Hirokawa[1], Hui-Chun Chu[4], Brendan Flanagan[5] and Yoshiyuki Tabata[1]

[1]Research Institute for Information Technology, Kyushu University, Fukuoka, Japan // [2]Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taipei, Taiwan // [3]Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taipei, Taiwan // [4]Department of Computer Science and Information Management, Soochow University, Taipei, Taiwan // [5]Graduate School of Information Science and Electrical Engineering, Kyushu University, Fukuoka, Japan // yin@cc.kyushu-u.ac.jp // hanyu.sung@gmail.com // gjhwang.academic@gmail.com // hirokawa@cc.kyushu-u.ac.jp // carolhcchu@gmail.com // bflanagan.kyudai@gmail.com// tabata@cc.kyushu-u.ac.jp *corresponding author

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ABSTRACT

With the popularity of the Internet, online searching is becoming an important part of learning. In this paper, based on the "Learning by Searching" theory, a learning environment is developed, which includes a search engine to assist students in recognizing the progression of trends and keyword transitions for specific domains. To efficiently support research trend surveys, an automatic data accumulation and classification approach is proposed to construct the database excerpts instead of manual keyword registration or any other heuristic preprocesses. With an associative search module, the search engine dynamically searches for relevant words that are frequently used in the targeted academic field, and provides learners with effective visualizations to understand the trend transitions. An experiment has been conducted on a college information management course to show the effectiveness of the proposed approach. The experiment results show that the students who learned with the new approach had significantly better learning performance in terms of recognizing the trend transitions of the targeted issues than those who learned with conventional search engines.

Keywords

Learning by searching, Web-based learning, Search engine, Data mining, Research trend survey

Background and objectives

With the advancement and popularity of the Internet and search engine technology, fostering students' web-based information searching ability has become an important educational objective. Researchers have indicated that allowing students to learn as active and self-directed participants is one of the greatest benefits of web-based learning activities, which often involve information searching tasks (Bilal, 2000; Hwang, Tsai, Tsai, & Tseng, 2008). In the past decade, various issues concerning information-seeking have been studied, such as the skill of processing the searched information (Chiou, Hwang, & Tseng, 2009) and the development of new environments that facilitate teachers' observation and analysis of the information-seeking behaviors of students in web-based learning environments (Tseng, Hwang, Tsai, & Tsai, 2009). Moreover, the correlates of teachers' epistemological beliefs concerning Internet environments, online search strategies, and search outcomes have been investigated (Tsai, Tsai, & Hwang, 2011).

In the meantime, researchers have indicated the difficulty of fostering students' higher order thinking competences, such as "Evaluate" and "Analyze" in Bloom's taxonomy of educational objectives (Bloom et al., 1956; Anderson et al., 2001; Hwang, Chu, Lin, & Tsai, 2011). Although the existing search engines cater to students' basic knowledge acquisition, they are not categorized into special research areas, making it difficult to address the specific, unique needs of individual learners. The question is how to design better search engines that address users' learning needs and knowledge levels. An ideal search engine should not only show the retrieval results, but also the analysis. Fortunately, technologies can accelerate learning and boost creativity. With the development of technologies such as data-processing, it is possible to design better search engines to address learning needs. Data-processing includes functions such as search engines, data mining, recommendations, and so on.

Moreover, with the development of technology, the longevity of paper-based literature has become very short. Researchers need to update their knowledge constantly in order to keep up with technological advancements. Hwang and Tsai (2011) indicated that "analysis results could help policymakers in governments and researchers in professional organizations to allocate the necessary resources and make plans for supporting future research and applications." They also indicated that doing surveys could provide good references for educators and researchers who plan to contribute to the relevant studies. Therefore, it is essential to conduct surveys to have both a wide and a deep understanding of related research; in particular, for those students who are just beginning to engage in academic research, research trend surveying is an essential preliminary step for any academic research (Hwang & Wu, 2012; Karatas, 2008). Doing an academic research survey can foster their competences of collecting the information related to a specific topic, evaluating the collected data, and analyzing the trends in the field. Unfortunately, although students can gain knowledge by using the current search engines such as Google or Yahoo!, many novice researchers have difficulty analyzing the collected data without proper support from the learning environment. Therefore, it is necessary to create search engines which are dedicated to supporting the acquisition of knowledge according to the special research area, to effectively supporting "learning by searching".

In this paper, a learning system, "Milky Way Research Trend (MWRT)," that includes a search engine for supporting research trend surveys for scientific literature is proposed. The search engine provides students with an efficient literature survey tool, which not only allows access to the needed data, but also presents the analysis results of the trends. Instead of manual keyword registration or any other heuristic preprocesses, the search engine dynamically searches for relevant words that are frequently used in the targeted academic field, and presents the findings in a visual format to help students understand the trend transitions. With this system, students can perform trend analyses, automatically extract outlines from the literature, and analyze the targeted documents as a time-series.

To evaluate the effectiveness of the proposed approach, an experiment has been conducted in a college information management course to investigate the following research questions:

1. Do the students who learn with MWRT show better learning outcomes in trend analysis than those who learn with the conventional learning approach for trend analysis?
2. Are there significant differences between the cognitive loads of the students who learn with MWRT and those who learn with the conventional learning approach for trend analysis?
3. Do the students who learn with MWRT reveal different technology acceptance degrees than those who learn with the conventional learning approach in terms of perceived ease of use and perceived usefulness?

Learning by searching

Searching is a natural learning behavior

Searching is a natural learning behavior like listening, speaking, reading or writing. There are many reasons for people to seek information. Sometimes people search for information because of curiosity; that is, they want to know why. Sometimes they search for information purely for their need to solve problems or complete tasks. Whatever the actual reason, the information searching process is a cognitive process that acquires knowledge actively, which is defined as a way of learning referred to as “learning by searching” in this study.

There are many kinds of learning strategies, such as learning by attending classes, learning from informal incidents, learning by doing, learning by gaming, and learning by searching. Among these learning strategies, learning by searching can foster students’ ability to take the initiative to acquire knowledge (Hwang, Tsai, Tsai, & Tseng, 2008). This research advocates learning by searching. It is a method for promoting "discovery learning," which is an inquiry-based, constructivist learning theory. Discovery learning takes place in problem solving situations where the learner draws on his or her own past experience and existing knowledge to discover facts and relationships and new truths to be learned (Bruner, 1967). Students interact with the world by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments. Bruner suggested that students are more likely to remember concepts if they discover them on their own. Several studies have reported the importance of engaging students in discovery learning tasks using search engines to seek information. For example, Bilal (2000) pointed out the importance and necessity of engaging students in searching for information on the Internet; in the meantime, he also indicated that, for those students who are unfamiliar with the usage of search engines, incorrect or inappropriate

information is likely to be derived. Accordingly, Hwang and Kuo (2011) proposed an information-summarizing instruction strategy to help students improve their information-searching ability. They found that, with proper supports, the students' ability of using keywords, selecting information resources and extracting important content can be improved. Kuo, Hwang and Lee (2012) further defined the learning approach that employs search engines to search for information to answer a series of questions related to a specific topic as "web-based problem solving."

Most of the studies concerning web-based information seeking employ the existing search engines to support discovery learning or web-based problem solving. Such an approach might be helpful to students in collecting data to complete reports for specific learning tasks, or finding information to answer a series of questions. However, to support students in investigating the trends of specific research topics or in analyzing the shifts of technology advancements and applications, more effective tools are needed. In this study, an innovative search engine that helps students organize the searched knowledge in order to improve their trend-awareness ability is proposed to cope with this problem.

Categories of knowledge

Searching can be perceived as a process of acquiring knowledge. When seeking knowledge on the Internet, people often represent their quests with one of the following “5W1H” questions (Tseng & Hwang, 2007); that is, “What”, “Where”, “Which”, “Who”, “When” and “How”. Researchers have indicated that knowledge can be divided into two categories; one is ability, which includes “know how”, “know what”, “know when” and “know who”; the other is related to knowing where to find the knowledge needed, which includes “know where” and “know which”. As shown in Figure 1, ability is supplemented with knowing where. As knowledge continues to grow and evolve at a rapid pace, access to what is needed is more important than what the learner currently possesses (Siemens, 2004).

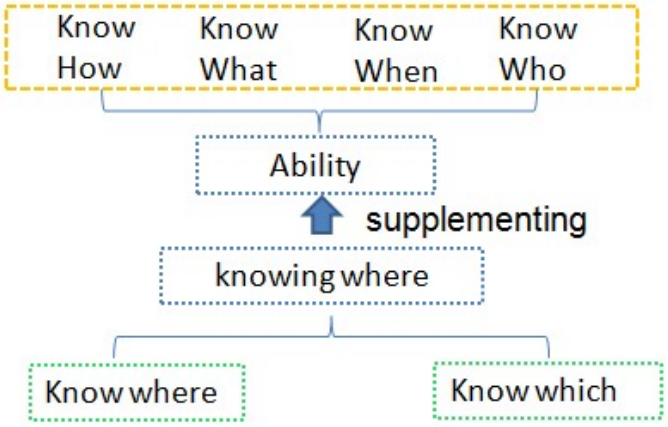

Figure 1. Knowledge Relationships

With the advancement and popularity of the Internet and search engine technology, online information searching is recognized as being a part of learning and a required learning skill for students (Liu, 2008). Researchers have attempted to investigate the cognitive processes underlying information searching. For example, State (2009) examined the search habits of 72 participants while conducting a total of 426 searching tasks. It was found that search engines were mainly used for checking the learners' own internal knowledge via comparing the knowledge with the searched facts, meaning that information searching is a learning process rather than simply a way of obtaining information.

This study aims to develop a learning system with a search engine which is able to advise students how to organize the collected trend information as well as how to find the information for solving practical problems. Via using the learning system, the students learn to recognize the research trends in depth through selecting keywords, setting search parameters and interpreting the search results.

System description

The data processing procedure consists of three stages; that is, “data collection,” “development of the search engine,” and “data analysis using the search engine.”

Data collection

The MWRT search engine was populated with 13,326 articles and papers from SciVerse Scopus (http://www.info.sciverse.com/scopus/) that were published from the year 1992 to 2012, and which contained the keyword “e-learning”. This data set was used in the analysis conducted in this paper. The original "SciVerse Scopus" database system does not provide any tools for high level analysis of the documents obtained. Therefore, a special search engine was developed for performing high level analysis of the documents collected.

Development of the search engine

The learning system was developed on an Apache server using the Linux operating system and the Perl programming language. The learner enters the keywords about his/her research field to search for relevant data. The relevance of inputted keywords is calculated by our system using co-occurrence frequency. This means that if a word has a higher relevance to the keywords given in the abstracts of papers (i.e., co-occurrence frequency), these words are listed as feature words. Subsequently, the system gives the user effective visualizations to understand the research trend transitions.

Data analysis using the search engine

The MWRT system provides an efficient tool to assist students in doing research trend analysis. Using the MWRT search engine, students can perform trend analyses, automatically extract outlines from the literature, and analyze documents as a time-series. Figure 2 shows the interface of the system. The user can control the MWRT search engine by changing certain inputs and parameters (a) as displayed in Figure 2. Based on these, the results (b) are then output as displayed in Figure 3.

(a) Input query and parameters

1: Search query string; 2: Enable advanced search settings display; 3: Enable detailed results output; 4: Number of top ranked keywords for each year; 5: Number of top ranked keys for each year; 6: Results sorting method; 7: Number of top ranked countries for each year; 8: Year range; 9: Number of top ranked authors for each year; 10: Threshold of the minimum number of top ranking years; 11: Number of top ranked sources for each year; 12: Toggle to display results as dots instead of numeric output; 13: Number of top ranked organizations for each year.

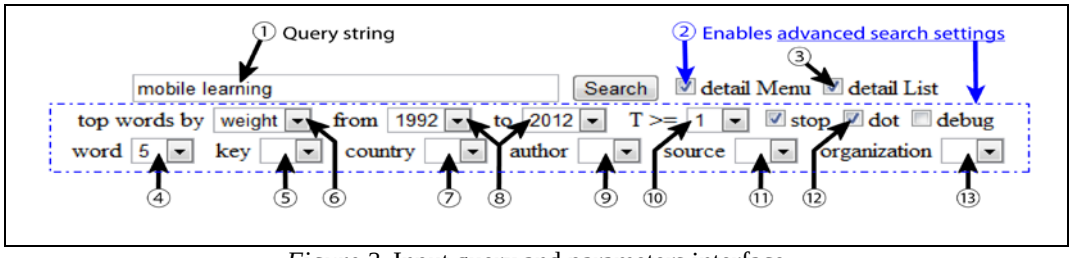

Figure 2. Input query and parameters interface

(b) Results output

1: Total number of articles containing the query string; 2: The number of years the item was top ranked; 3: The number of articles that contained the item in the top ranked years; 4: The total number of articles that contain the item; 5: The Milky Way which displays the top ranking years for each item.

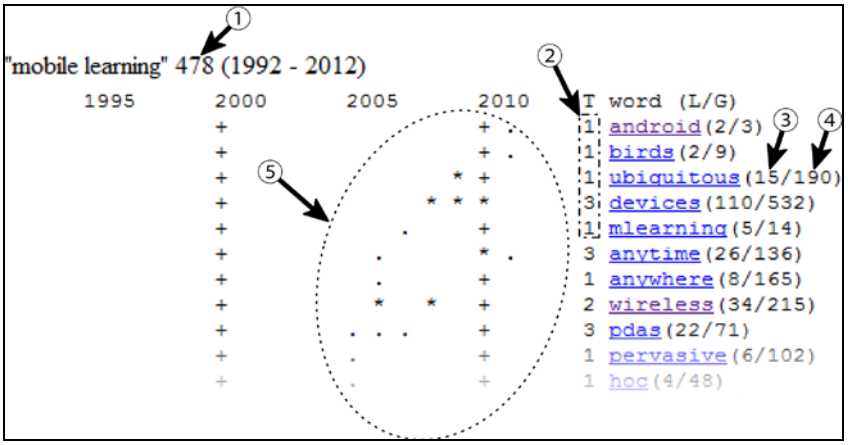

Figure 3. Results output interface

Analysis examples

To demonstrate the effectiveness of the system, several practical applications of analyzing research trends with MWRT are given in this section.

Research trends overview by feature words

In the following, an illustrative example of investigating research trends of mobile learning is given to demonstrate the "Overview by Feature Words" function of the learning system. In this case, the analysis was conducted using the keywords “mobile learning” in the MWRT search engine and the number of top ranked keywords to be returned for each year was set to five.

Some definitions of “mobile learning” describe it as the act of learning while on the move. In more recent times the definition has become associated with the use of mobile computing devices used to facilitate the act of learning (Laouris & Eteokleous, 2005). It is hypothesized that this has been spurred by advances in mobile communication devices, such as laptops, mobile phones, smart phones and more recently tablet computers (Ha et al., 2009). The MWRT search engine was used to analyze the research trends in mobile learning to test this hypothesis.

The results of the analysis are displayed in Figure 4. As observed in 2005, three technology-related keywords emerged as possible research trends, “phones”, “pdas” and to a lesser extent, “hoc”. On further investigation into the usage of these keyword it was determined that “pdas” referred to the use of Personal Digital Assistants or Pocket PCs, while “phones” referred mainly to the use of mobile (cellular) phones and Smartphones used to facilitate learning in a mobile environment. The keyword “hoc” was found to refer to “ad hoc” wireless communication networks. These keywords focus on hardware based technologies that are used to support mobile learning.

The keyword “wireless” comes to light in 2006 with additional research conducted in wireless Internet and network communications, as well as research into the use of near field wireless communication, such as Bluetooth personal area networks and infrared data communications. In 2008 the keyword “devices” appears as a research trend. On further investigation it was found to refer to the use of Smartphones, Pocket PCs, PDAs, mobile phones, portable computers (such as laptops and notebooks) and to a lesser extent, mobile music players, and digital dictionaries. Up until this point hardware based technologies were dominant in the research trends analysis results.

The most recent keyword, “android”, first surfaced in 2011 as a reference to the Android Smartphone operating system software by Google which has grown in consumer market popularity in recent years since its release in 2008 (The Nielsen Company, 2011). This change in the trend from hardware to software based technologies may suggest that future research trends will focus on emerging mobile software platforms as opposed to previously dominant hardware devices.

This trail of keywords returned in the results from the MWRT search engine suggests that a technology driven research trend in mobile learning exists and offers possible insight for novice research students into the change from hardware to software technology based research.

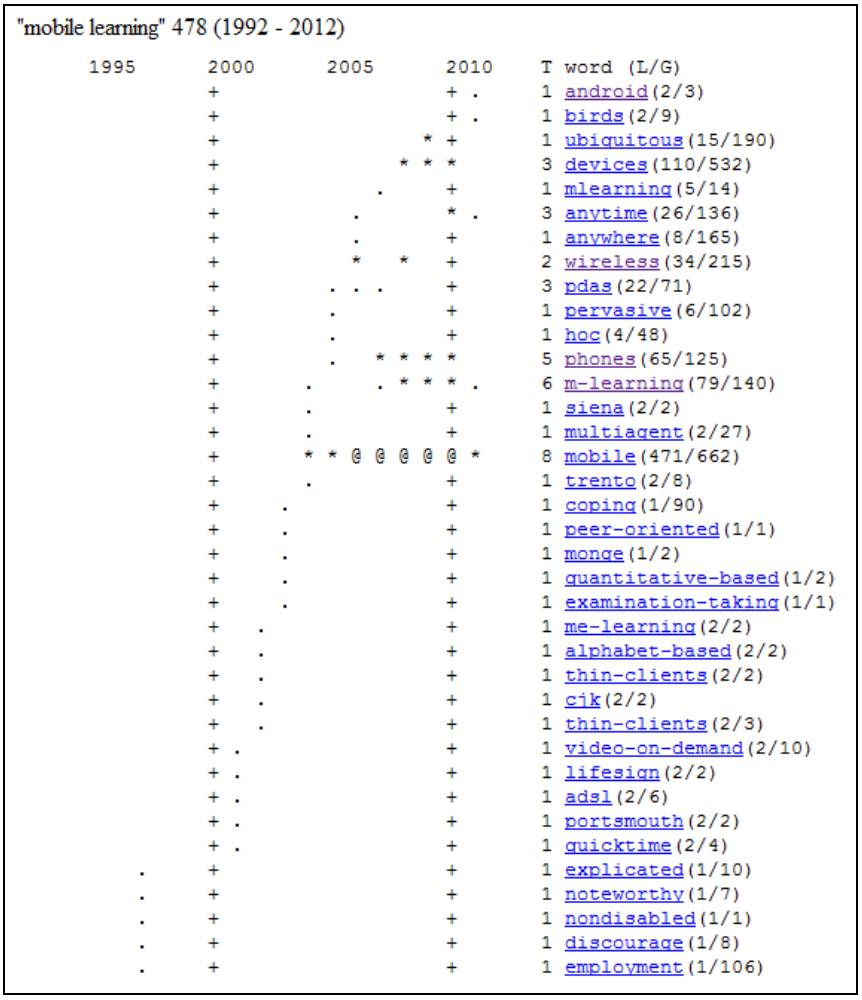

Figure 4. The Milky Way of "mobile learning" feature words

Comparison of research trends by country

Using the MWRT search engine to compare the research trends of countries initially returned the results as displayed in Figure 5, with the United Kingdom, Spain, and more recently China and Taiwan as countries with strong research. Further detail was obtained using multiple results from the MWRT search engine to build a view of the trend in the number of published articles relating to mobile learning published by country as displayed in Figure 6. The four top ranking countries in mobile learning research by number of articles published are Taiwan, China, the United Kingdom, and Spain. The trends in the number of articles from these countries seem to share a common feature: the number of published articles increases noticeably after the year 2005 when compared to other countries. A novice research student might pose the question: what was the catalyst for the increase in research and published articles? On further investigation it was determined that government public policy might be a significant contributing factor.

In the case of Taiwan, a government driven program promoting e-learning could be linked to the dramatic rise in the number of published articles as described by Hwang (Hwang & Tsai, 2011). In 2005, China's Ministry of Education implemented policies regarding the future focuses of e-learning, thus possibly explaining the sudden increase in research and published articles originating from China (Gilsun, 2006). In the United Kingdom, the Department for Education and Skills' 2005 strategy, "Harnessing Technology", called for the research and development of e-

learning at all levels of education, which would explain the rapid increase in the number of published articles (Department of Education and Skills, 2005). The Spanish Government's Plan Avanza policy, which was ratified in 2005, outlined the advancement of ICT on both a societal and economic level, and is highly likely to be a key force behind the rise in research and in the number of articles published (van Ark, 2011).

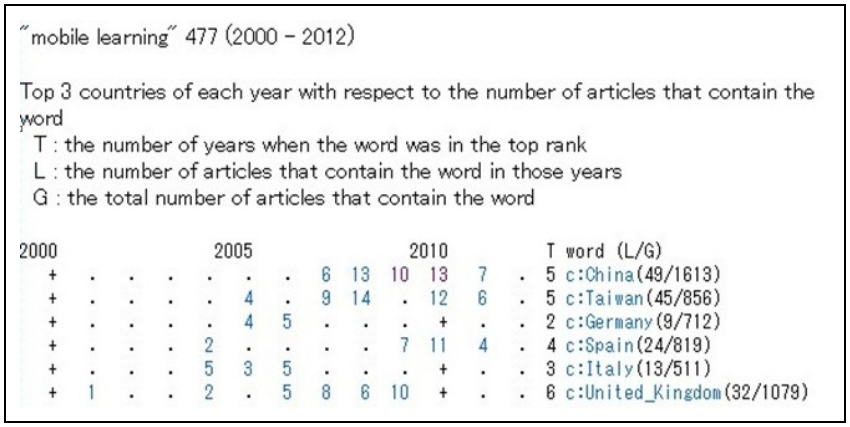

Figure 5. Number of articles published between 2000 and 2012 by country result

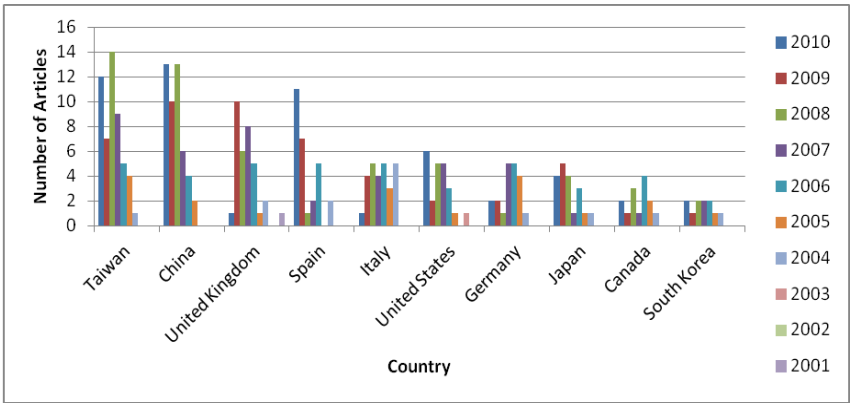

Figure 6. Number of articles published between 2001 and 2010 by country

Using multiple search results from the MWRT search engine to create an international view of research, as demonstrated, may help novice research students identify public or private sector influences that shape research trends within the field of mobile learning.

Detailed analysis of research trends in China, Japan and Taiwan

(a) China

The results from the analysis of keywords from China are displayed in Figure 7. A total of 55 articles were returned that included possible trend keywords. Of particular interest are keywords which relate to the way learning is undertaken. Keywords, such as: "anytime", "peer-to-peer", "ubiquitous" and "self-promotion" suggest that there might be a research trend related to peer based ubiquitous learning.

(b) Japan

In Figure 8 the results of the analysis of research trend keywords from Japan are displayed. A total of 19 articles were returned that included possible research trend keywords. While the total number is significantly less than those returned for China, the degree of keyword variation is similar. Both countries share in common the keyword

"ubiquitous" which has been highlighted as part of a possible trend. The keywords "pdas" and "phones" suggest that hardware device related research may have been an early trend. More recent occurrences may suggest that the trend has moved towards more software based research in mobile learning, such as "movie", "photos", and "browsers".

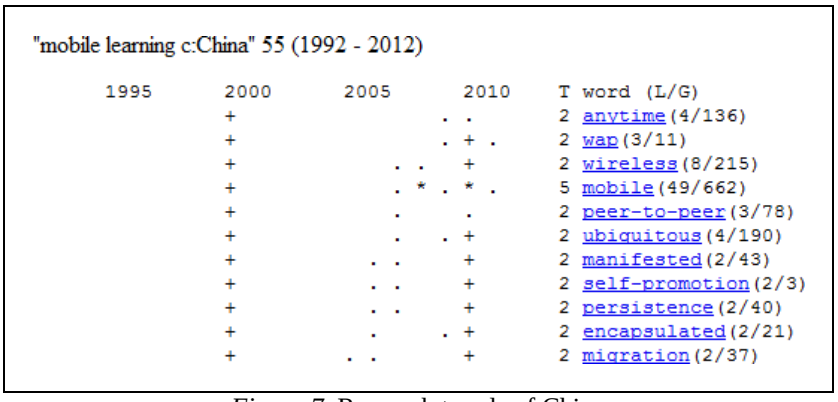

Figure 7. Research trends of China

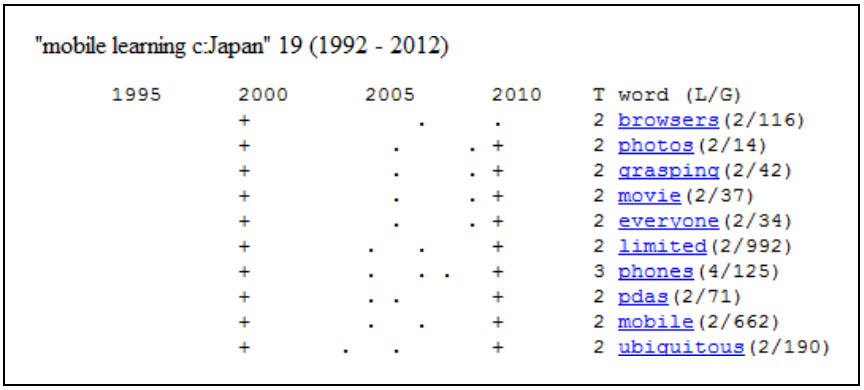

Figure 8. Research trends of Japan

(c) Spain

The results from the analysis of research trend keywords from Spain are displayed in Figure 9. A total of 32 articles were returned, which, along with the keyword variation, is moderate when compared to the previous results for China and Japan. The resulting keywords may suggest that the trends are mainly based around hardware related research, such as "desktops", "handhelds", "devices", "pdas", and "phones".

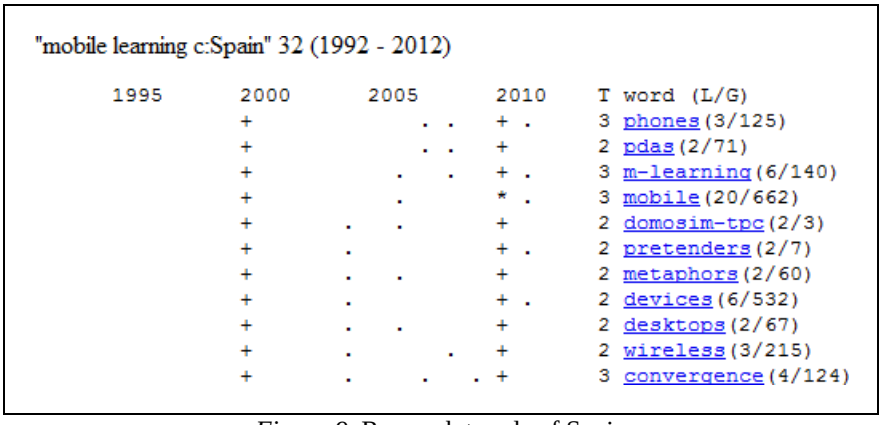

Figure 9. Research trends of Spain

(d) Taiwan

Analysis results from the search for research trend keywords from Taiwan are displayed in Figure 10. The total number of returned articles is an impressive 58, with a wide range of different possible research trend keywords when compared to the prevously reviewed countries, China, Japan, and Spain. Of particular interest is the rapid rise in the number of articles published around 2004 to 2005, as previously discussed, which could possibly be attributed to Taiwan's push into e-learning as described by Hwang (Hwang & Tsai, 2011).

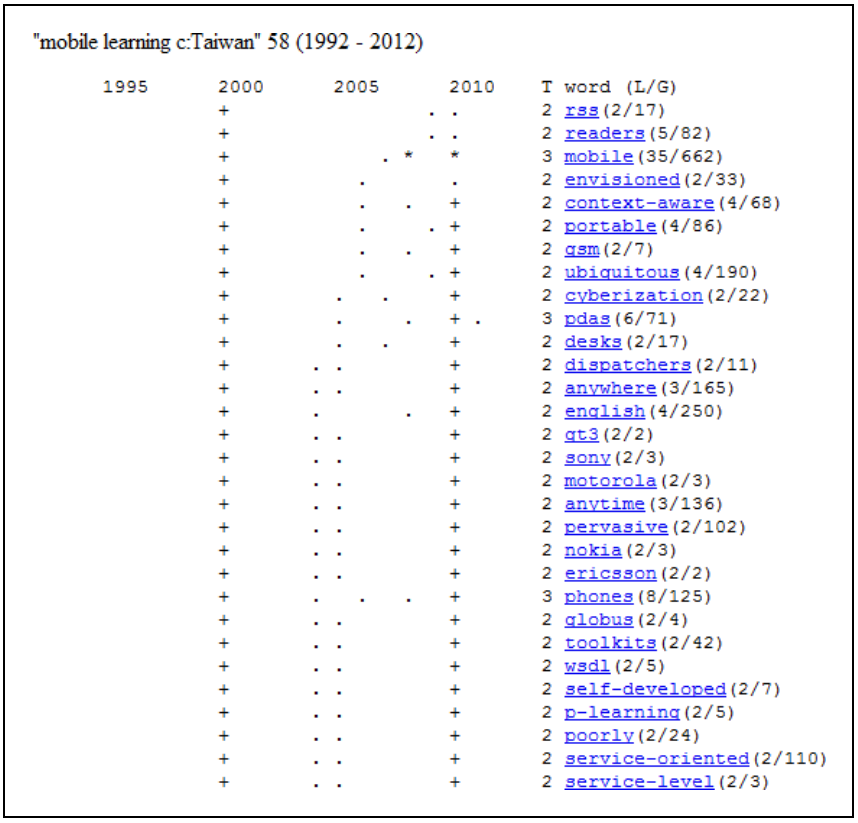

Figure 10. Research trends of Taiwan

Experiment design

To evaluate the effectiveness of the approach in helping students recognize the progression of trends and keyword transitions for specific learning topics, an experiment has been conducted on a college Information Management course. In the following subsections, the design of the experiment is described in detail.

Participants

The participants were two classes of sophomore students of a university in northern Taiwan. A total of sixty-nine students participated in the study, including twenty-five females and forty-four males with an average age of 20. One class was assigned to be the experimental group, and the other was the control group. The experimental group included thirty-six students (twelve males and twenty-four females), while the control group had thirty-three students (thirteen males and twenty females). In order to avoid the influence of different instructors on the experimental results, the two classes were taught by the same instructor. The experimental group learned with the MWRT search engine, while those in the control group learned with a search engine with a conventional interface (i.e., displaying the searched results by showing a list of document titles and abstracts). Both groups received the information-searching and summarizing instructions for analyzing the research trends of e-learning articles before the learning activity.

Measuring tools

The measuring tools of this study include a pre-test, a post-test, and several questionnaires for measuring students' cognitive load, satisfaction and acceptance of using the search engines.

The pre- and post-test were developed by two experienced teachers who had taught the Information Management course for a number of years. The pre-test aimed to ensure that both groups of students had the equivalent basic knowledge of using computer networks and search engines. It consisted of forty multiple-choice items. The post-test aimed to evaluate the students' learning achievement (i.e., their knowledge of the progression of trends and keyword transitions for specific learning topics) after participating in the learning activity. It consisted of twenty multiple-choice items related to the trends of the specific topic investigated during the learning activity. Both the perfect scores of the pre-test and post-test were 100.

The cognitive load questionnaire was modified from the cognitive load measure developed by Sweller, van Merriënboer and Paas (1998). It consisted of 4 items in the two dimensions of “mental load” and “mental efforts” on a six-point Likert scale, where “6” represented “strongly agree” and “1” represented “strongly disagree.” The Cronbach's α value of the cognitive load questionnaire was .79, showing good reliability in internal consistency.

The questionnaire of technology acceptance of using search engines was developed based on the questionnaire developed by Hwang, Wu, Tseng, and Huang (2011). It consisted of 13 items, including 7 items for perceived ease of use and 6 items for perceived usefulness with a seven-point Likert scale. The Cronbach's α values of the two questionnaire dimensions were .89 and .94, respectively. In addition, three open-ended items were used to collect opinions from the students after experiencing using the search engine.

Experimental procedure

The experiment was conducted on a unit of an Information Management course in a university. The objective of the unit is to teach students the notation of literature surveys, including the progression of trends and keyword transitions for specific learning topics.

As shown in Figure 1, before the experiment, the students took a pre-test for evaluating their basic knowledge of using computer networks and search engines. Before the learning activity, an orientation was given to introduce the learning tasks and the learning system. Following that, a 150 minute learning activity was conducted. Both the experimental and control groups were asked to search for information to answer a series of questions related to a research issue, such as "What is the trend of research methods and tools related to this issue in the past decade" and "Compare the studies conducted by researchers of five countries and report the differences and similarities between their studies in terms of subjects, methods and tools." The students in the experimental group learned with the MWRT search engine, whereas those in the control group learned with the conventional search engine. After the learning activity, a post-test was conducted; moreover, the students were also asked to complete the cognitive load and the technology acceptance questionnaires on completion of the post-test.

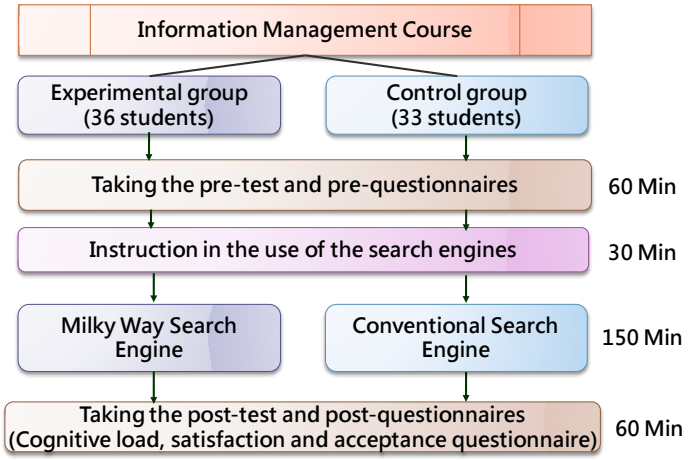

Figure 1. Diagram of experiment design

Experimental results

In the present study, the collected data were first examined by descriptive statistics to explore the group means, standard deviations and numbers. Then, t-tests and analysis of covariance (ANCOVA) were conducted to examine the effects of using the proposed approach on students' learning achievements in recognizing research trends and their perceptions of the learning activity. In addition, the technology acceptance degrees of the students were analyzed as well.

Analysis of learning achievement

The aim of this study was to examine the effectiveness of the MWRT search engine in helping students identify possible trends in specific fields. From the pre-test, it was found that the mean values and standard deviations were 62.99 and 7.09 for the experimental group, and 60.08 and 6.97 for the control group. The t-test result (t = 1.71, p >.05) shows that there was no significant difference between the two groups; consequently, it is concluded that the two groups had equivalent prior knowledge before the learning activity, as shown in Table 1.

Table 1. Descriptive data and t-test result of the post-test results

Variable	Group	N	Mean	S.D.	t
Pre-test	Experimental group	36	62.99	7.09	1.71
	Control group	33	60.08	6.97	

After the learning activity, the analysis of covariance (ANCOVA) was used to test the difference between the two groups by using the pre-test scores as the covariate and the post-test scores as dependent variables. Table 2 shows the ANCOVA results of the post-test. The adjusted mean value and standard error of the post-test scores were 83.97 and 1.52 for the experimental group, and 77.98 and 1.59 for the control group. According to the results (F = 7.24, p < .01), there was a significant difference between the two groups; that is, the students who learned with the MWRT search engine showed significantly better learning achievements than those who learned with the conventional search engine, implying that the MWRT search engine is helpful to students in recognizing the progression of trends for specific learning topics.

Table 2. Descriptive data and ANCOVA result of the post-test results

Variable	Group	N	Mean	S.D.	Adjusted Mean	F
Post-test	Experimental group	36	84.56	1.52	83.97	7.24**
	Control group	33	77.33	1.59	77.98	

** p < .01

Analysis of cognitive load

In addition to learning achievement, it is worth investigating whether the new search engine increases the learning pressure of the students. Consequently, the cognitive load measure was used to compare the pressure of the students from two aspects; that is, mental load and mental effort. The former is concerned with pressure caused by the amount of information presented to the learners, while the latter is related to pressure caused by the way of structuring the information (Sweller, van Merriënboer, & Paas, 1998; Hwang & Chang, 2011).

Table 3 shows the t-test results for the mental load and mental effort scores of the two groups. In terms of mental load, the mean and standard deviation were 3.10 and 1.06 for the experimental group, and 2.91 and 0.97 for the control group; in terms of mental effort, the mean and standard deviation were 3.69 and 1.27 for the experimental group, and 3.17 and 1.16 for the control group. The t-test results show that there was no significant difference between the two groups in either dimension, implying that the MWRT search engine did not increase the cognitive load of the students although its user interface does seem complicated.

Table 3. Descriptive data and t-test result of the cognitive load

Variable	Group	N	Mean	S.D.	*t*
Mental Load	Experimental group	36	3.10	1.06	0.76
	Control group	33	2.91	0.97	
Mental Effort	Experimental group	36	3.69	1.27	1.80
	Control group	33	3.17	1.16	

Analysis of technology acceptance

Table 4 shows descriptive statistics of the feedback from the students in the experimental group and control group to the questionnaire items of technology acceptance of using the search engines. For the aspect of perceived usefulness, the means were 3.80 for the experimental group and 3.11 for the control group; moreover, the t-test result ($t = 3.04$, $p < .01$) for this dimension shows that there was significant difference between the two groups, implying that the students in the experimental group showed strong recognition of the usefulness of the MWRT search engine in helping them conduct trend surveys.

On the other hand, the t-test result ($t = 1.13$, $p > .05$) on the "ease of use" dimension shows that there was no significant difference between the two groups, implying that the MWRT search engine was identified by the students as an easy-to-use system much the same as conventional search engines although it was absolutely new to them.

Table 4. Results of questionnaire of acceptance and satisfaction with the search engine

Variable	Group	N	Mean	S.D.	*t*
Perceived usefulness	Experimental group	36	3.80	0.81	3.04**
	Control group	33	3.11	1.03	
Perceived ease of use	Experimental group	36	3.63	0.81	1.13
	Control group	33	3.39	0.98	

** $p < .01$

In addition, the students' feedback to the open-ended questions showed that most of the students in the experimental group preferred to use this innovative way to engage in literature retrieval and content analysis in the future. More importantly, some encouraging responses were derived from the students. One of the students stated that “This learning activity is very helpful to novices who have just started to study a topic. It makes my trend survey process more efficient.” Another student expressed that, “This way of learning has motivated me to look for more information for understanding the topic in depth.” One student further indicated that “In the beginning, I felt it difficult to memorize the functions of this search engine, but soon I learned the skills of using it. I am very happy to have this opportunity to experience using this search engine. It is a useful system and a very innovative way to help us analyze the trends of the topic.”

Conclusions and future work

For the students who are novices in a field, it is essential to conduct literature surveys (Shih et al., 2008). However, as has been indicated by researchers, the existing methods or tools for supporting research trend surveys are inefficient. For example, when doing content analysis, the research topics are first categorized into several tentative categories and sub-categories, and are refined manually and continually by using the constant-comparative method. Moreover, all the selected articles need to be coded manually based on different types of categories referring to their abstract. In addition, highly cited papers need to be further selected to analyze their research participants, research setting, research design and methods (Tsai & Chi, 2011; Tsai & Chiang, 2011). It can be seen that doing such a survey is time-consuming; more importantly, the students spend most of their time categorizing and coding data instead of evaluating the findings and reorganizing their knowledge with conventional approaches.

Jonassen, Carr and Yueh (1998, p. 1) indicated that "Technologies should not support learning by attempting to instruct the learners, but rather should be used as knowledge construction tools that students learn with, not from.” They further pointed out that learners need tools that help them to access and process that information; moreover, a

new class of intelligent information search engines can be effective Mindtools to help learners construct knowledge via scanning information resources and organizing the information in a meaningful way.

Conventional search engines, such as Google or Yahoo!, only provide simple information searching and summarizing functions. The learning system proposed in this study not only provide a framework to guide learners determine the keywords and parameters for trend-related information searching, but also presented the searched information in visualized forms (e.g., a time series) via classifying and analyzing the retrieved information, which help learners realize how information can be interpreted and organized for trend analysis. Such a process of searching for, organizing and interpreting information is indeed a form of knowledge construction as indicated by Jonassen and Carr (2000). In the post-test, the students were asked to answer a series of questions related to the trends of a specified research issue that they had not surveyed before; that is, they needed to determine keywords and parameters for collecting information before analyzing the trends of the issue. From the experimental results, it was found that the students in the experimental group showed significantly better performance in answering the trend-related questions of the target issue than those in the control group, implying that MWRT is able to improve their abilities of searching for information as well as interpreting the collected information for trend analysis. From the experimental results, it is concluded that the proposed approach is able to improve the students' awareness of the trends of specific topics. It is also interesting to find that the developed search engine has been identified by the students as an easy-to-use tool much the same as conventional search engines, although it is new to them and its interface seems more complicated. The analysis results of the cognitive load of the students also support the finding that the innovative approach is able to assist students in analyzing the searched data without increasing their mental pressure.

It should be noted that MWRT is not the only system that provides search results by summarizing searched data over time. For example, Google Trends is a well-known system that presents search results as charts in which the horizontal axis represents time and the vertical shows the frequency of people using the keywords in comparison with the total search times. Although both Google Trends and MWRT show the frequency of a term used over time and display the search results as a chart, their functionalities are quite different in several ways. The most crucial differences are the data sources and the mechanism of selecting keywords to be compared. Google Trends analyzes the queries of users and searches for data provided by Internet users; on the other hand, MWRT analyzes scientific articles from a database which can be updated or maintained by researchers or teachers. Moreover, the target keywords for comparison need to be specified by the user in Google Trends, while MWRT extracts the related keywords automatically based on the user's query. Therefore, MWRT is more like a learning tool that allows researchers or teachers to provide data related to a specified learning purpose; in the meantime, it serves as a supporting tool for showing students how to organize the searched data for trend analysis.

In comparison with previous studies that used the content analysis method to identify research trends in the field of e-learning, this “learning by searching” system provides a more efficient and effective environment to foster the research trend survey ability of students. Therefore, such an approach can cope with the problem indicated by researchers that the lack of proper supports or tools might cause students to pay too much attention to the data collection and pre-processing stages, while the evaluation and analysis of the collected data are often ignored or briefly done (Chiou et al., 2009). It also conforms to the conception of Mindtools proposed by Jonassen and Carr (2000) that technology can be used as a Mindtool to engage students in higher order thinking that is necessary for meaningful learning.

On the other hand, the students made some negative comments about the use of MWRT; in particular, they felt that its interface is complex and the symbolic icons are difficult to follow, especially at the beginning of the learning activity. Consequently, in the near future, we plan to improve our system by providing a more easy-to-use interface. Moreover, we also plan to investigate the students' proactive attitude (Schmitz & Schwarzer, 1999), which is a belief in the potential of changes that can be made to improve oneself and one's environment by considering various facets such as resourcefulness, responsibility, values, and vision. Such a personality characteristic is highly related to trend analysis as well as the implications for motivation and action.

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