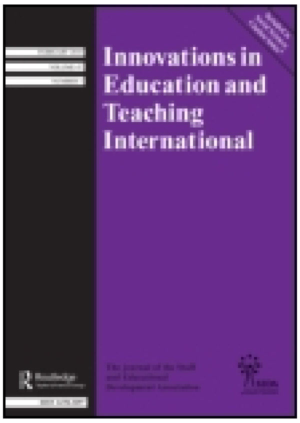


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# Information searching strategies in web-based science learning: the role of internet self-efficacy

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# Information Searching Strategies in Web-Based Science Learning: The Role of Internet Self-Efficacy

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## SUMMARY

The purpose of this study was to explore students' information searching strategies in Web-based science learning activities and further examine the influence of students' Internet self-efficacy on these strategies. Eight subjects were randomly selected from a pool of 73 college freshmen based on mixed genders and Internet self-efficacy levels. In-depth case studies and comparisons were used to analyse subjects' Web-based searching and learning achievement, online searching strategies and the role of Internet self-efficacy. The results showed evidence that high Internet self-efficacy students had better information searching strategies and learned better than those with low Internet self-efficacy in a Web-based learning task. This study further proposed a framework for analysing Web-based searching strategies. This study also reflected the importance of explicitly helping students acquire better metacognitive Web searching strategies.

## INTRODUCTION

In the last decade, integrating technology into science teaching has been recognized as one of the important issues for educational reform and innovations (e.g. AAAS, 1989, 1993, 1998). In recent years, the efficiency and popularity of the Internet has received much attention that has motivated efforts towards integrating Web-based learning activities into the curriculum (Khan, 1997; Chang, 2001; Tsai *et al.*, 2001). One of the greatest benefits of Web-based learning activities is to allow students to participate in learning as active and self-directed participants (Tsai, 2001a, 2001b). However, students with experiences only of traditional didactic teaching methods may have problems adapting to this new approach (McCormack and Jones, 1998).

According to Bandura (1996), self-efficacy influences people's choice of activities, how much effort they will expend, and how long they will sustain effort in dealing with stressful situations. Self-efficacy expectations toward emerging traditional computer-based learning systems are likely to influence how participants use the system (Hill *et al.*, 1987; Oliver and Shapiro, 1993; Kinzie *et al.*, 1994). Users with low self-efficacy lack confidence in their ability to use the system to achieve desired results; therefore, they are more likely to accept rather than question system-generated information. In contrast, users with high self-efficacy tend to be more persistent in their learning and more confident in their ability to use the system (Murphy, 1988).

Web-based learning activities often involve information searching tasks, as web-based environments are connected with information sites worldwide. However, it appears to be difficult for Internet novice users to search information effectively and efficiently through the web (Borgman, 1986; Marchionini, 1995). Disorientation is one of the problems that novice explorers tend to have while navigating within a hyperspace (Dias *et al.*, 1999). It has been reported that users' cognitive strategies, especially information processing skills, determine a successful search on the Internet (Hill and Hannafin, 1997; Hess, 1999; MacGregor, 1999). It is, therefore, important to examine the influence of students' Internet self-efficacy on

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their information searching strategies in Web-based science learning environment. In summary, the purpose of this study was to explore a group of college students' information searching strategies in Web-based science learning activities and examine the role of students' Internet self-efficacy on these strategies.

## METHODOLOGY

The methodology used in this study was a multiple-case study followed by cross-case comparisons. This study first used an instrument to select subjects with different degrees of Internet self-efficacy from a larger group of college students. These selected subjects then served as cases for in-depth case studies. The comparisons were focused on exploring the differences between students' Web-based searching and learning achievement, online searching strategies and the role of Internet self-efficacy.

### Instrument

This study developed an instrument surveying student Internet experience and self-efficacy. The instrument first surveyed the respondent's Internet experience, for example, in terms of Internet training, years of using the Internet and weekly online hours. The second part of the instrument included the following six items for assessing respondent's Internet self-efficacy:

(1) I think I know how to use a Web browser like 'Internet Explorer' or 'Netscape Navigator'.
(2) I think I know what 'Yahoo!' is about.
(3) I usually feel lost or confused when I am seeking information on the WWW.
(4) I am good at searching for information on the Web.
(5) I am confident in handling a Web browser like 'Internet Explorer' or 'Netscape Navigator'.
(6) I think I am the kind of person who can make good use of the Internet.

The items were presented on a 5-point Likert scale that ranged from 1 (totally disagree) to 5 (totally agree). Hence, the total scores for these six items ranged from 6 to 30 (the score of the third item should be reversed before summing). Respondents having higher self-efficacy would gain higher scores. The internal consistency reliability (alpha) for the six items calculated from 73 college students (described later) was 0.80.

### Subjects

Seventy-three college students enrolled on an Information Education course in a university in Taiwan were used as a pool for sampling. The pool consisted of 37 males and 36 females, aging from 19 to 21. The course was a computer course at an introductory level and was required for all freshmen.

The instrument mentioned above was given to individuals in the pool. Students' average score on the self-efficacy instrument was 16.85 (S.D.= 3.66, range = 9–26). This mean score was used to categorize the students into two pools: one was a pool of low Internet self-efficacy (lower than 16.85) and the other was a pool of high Internet self-efficacy (higher than 16.85). Four subjects were then randomly selected from each pool with an equal split of gender. Information about the eight subjects is summarized in Table 1. It should be noted that subjects who were categorized as having 'expert' Internet experience had either attended at least one course on Internet applications or had more than one year of experience using the Internet. Otherwise, they were labelled as 'novice' regarding Internet using experience.

Table 1 clearly shows that the Internet novice subjects held low Internet self-efficacy and the Internet experienced subjects held high Internet self-efficacy. This may indicate that limited experience restricted students' expectations of their own abilities in using the Internet.

### Learning task

The eight subjects were individually scheduled to perform a Web-based science-learning task. The goal of the task was to acquire basic concepts of nuclear power and the usage of nuclear power in Taiwan by searching for related knowledge and information on

**Table 1** *Gender, Internet self-efficacy and Internet experience of subjects*

| Subject ID | Gender | Internet self-efficacy | | Internet experience |
|---|---|---|---|---|
| | | Score | Level | |
| 1 | F | 20 | High | Expert |
| 2 | F | 14 | Low | Novice |
| 3 | F | 18 | High | Expert |
| 4 | F | 12 | Low | Novice |
| 5 | M | 13 | Low | Novice |
| 6 | M | 19 | High | Expert |
| 7 | M | 20 | High | Expert |
| 8 | M | 9 | Low | Novice |

the WWW. This learning task was set in response to a major science education reform in the past two decades, called STS (Science-Technology-Society) instruction. This is an integrated or interdisciplinary science curriculum highlighting the interplay among science, technology and society (e.g. Yager and Tamir, 1993; Tsai, 1999, 2000).

In this learning task, each subject was given a working sheet with five questions. Blank spaces on the working sheet were provided for answers or notes. These questions are listed as follows:

(1) What is nuclear power?
(2) What are the advantages of nuclear power?
(3) What are the disadvantages of nuclear power?
(4) How many nuclear power plants are there currently in Taiwan?
(5) Where are the locations of the nuclear power plants in Taiwan?

While searching for answers, the subjects were asked to think aloud. That is, students had to say what they were thinking and doing while searching. The processes were videotaped for analysing students' information searching strategies. During these processes, students had to record the answers to the five questions on the working sheets. These answers were further analysed as an indicator of their 'searching achievement'. Each subject was given 30 minutes to finish the task. In order to understand how the subjects learned in this task, the eight subjects' domain knowledge before and after the task were measured by the same five questions. A pre-test was administered just before the learning task, and a post-test was administered two weeks after the learning task – both were conducted in a paper-and-pencil format. Subjects' 'learning achievement' was then defined as the difference between individual's pre-test and post-test of domain knowledge. As a result, this study included two tests about students' knowledge of nuclear power and a working sheet for recording answers found during the searching task. All of these tests and working sheets used the five questions described above. Students' answers to these questions for each test and sheet were evaluated by one science educator and further validated by another expert. Each of the questions was allocated up to two points (0 for incorrect, 1 for partial correct, 2 for correct), therefore, students' scores on each test could range from 0 to 10.

### Information searching strategy analysis

Subjects' information searching strategies were analysed by protocol analysis (Ericsson and Simon, 1993) and observations of their motor skills. Since subject 8 had trouble with thinking aloud while searching, limited information could be collected about his searching strategies. Therefore, subject 8 was excluded from further analysis. As a result, only seven subjects were included for a comparison. All data were compared and categorized for analysing information searching strategies in Web-based science learning.

Based on the experience of the researchers, a methodology based on the following criteria was used to describe subjects' verbalization and motor actions:

- *Control*: indicating the observed ease and comfort of using computers and the Internet.
- *Disorientation*: a reflection of being lost or confused when searching online.
- *Trial and error*: indicating whether the subject performed any thinking or skills or tried any possibility when he or she did not feel confident about searching.
- *Problem solving*: indicating whether the subject tended to solve problems by himself/herself or to ask others for help, when he/she had trouble while searching.
- *Purposeful thinking*: indicating whether the subject reminded himself or herself about what was the goal for searching.
- *Selecting main idea*: indicating whether the subject can grasp or summarize the main information provided in each Web page.
- *Evaluating information*: indicating whether the subject tended to accept or criticize the information provided in a Web page.

Students' verbalizations and motor actions when searching information on the Web were analysed based on the system above. This part of analysis represented their information searching strategies. The analysis was performed by the first author and further validated by a trained researcher.

## RESULTS

The results of subjects' searching and learning achievement are shown in Table 2. The averages of all subjects' searching achievement and learning achievement (post-test–pre-test) were 6.8 and +1.8 respectively. Based on the two scores, subjects were divided into two groups. For those whose searching achievement or learning achievement was below the average, the subjects were assigned to group 1.

**Table 2** *Results of searching and learning achievement*

| | Searching achievement (total 10 credits) | Learning achievement | | |
|---|---|---|---|---|
| | | Pre-test | Post-test | Post-test–Pre-test |
| Subject 1 | 10 | 6 | 9 | +3 |
| Subject 2 | 2 | 6 | 6 | +0 |
| Subject 3 | 7 | 6 | 8 | +2 |
| Subject 4 | 10 | 2 | 6 | +4 |
| Subject 5 | 2 | 7 | 7 | +0 |
| Subject 6 | 8 | 3 | 6 | +3 |
| Subject 7 | 8 | 6 | 8 | +2 |
| Subject 8 | 7 | 6 | 6 | +0 |
| Average | 6.8 | | | +1.8 |

**Table 3** *Results of the comparisons of searching achievement, learning achievement and Internet self-efficacy*

| | Group 1 (Subjects 2, 5, 8) | Group 2 (Subjects 1, 3, 4, 6, 7) |
|---|---|---|
| Searching achievement (min ~ max) | 2 ~ 7 | 7 ~ 10 |
| Learning achievement (min ~ max) | +0 ~ +0 | +2 ~ +4 |
| Internet self-efficacy level | Low | High* |

*Except for subject 4, all subjects in group 2 had a high level of Internet self-efficacy.



Otherwise, the subjects were assigned to group 2. Therefore, subjects 2, 5 and 8 were put in to group 1, and subjects 1, 3, 4, 6 and 7 were placed in group 2. The comparison of searching and learning achievement between the groups is shown in Table 3. In addition, according to the levels of Internet self-efficacy summarized in Table 1, it is interesting to notice that subjects in group 1 had low levels of Internet self-efficacy whereas subjects in group 2, except subject 4, had high levels of Internet self-efficacy. The analysis of results in Table 3 is based on these two groups of subjects, and a discussion of the particular case, subject 4, is analysed at the end of this section.

## Internet self-efficacy and web-based learning

According to Table 3, group 1 and group 2 were different in their searching achievement, learning achievement and Internet self-efficacy levels. Regarding the searching achievement, subjects in group 2 achieved higher scores (from 7 to 10 points) than did the subjects in group 1 (range from 2 to 7 points). That is, generally speaking, subjects with high Internet self-efficacy (ISE) tended to search more successfully than those with low ISE did. In addition, subjects' learning achievement, which was defined by the difference between their prior and post domain knowledge, was also found to be related to subjects' ISE. It is important to notice that the values of the difference between pre-test and post-test were 0 for group 1 but there was an increase of 2 to 4 points for group 2. That is, subjects with low ISE might learn nothing two weeks after the Web-based science-learning task, whereas those with high ISE did gain some know-ledge or change some concepts in this activity.

## Internet self-efficacy and information searching strategies

A comparison of the subjects' information searching strategies is presented in Table 4. It is obvious that the subjects in group 2 (in general, high ISE) were more skilful than subjects in group 1 (low ISE). The observed differences of online information searching strategies between users with high and low Internet self-efficacy apparent from Table 4.

Regarding control, members in group 2 were more confident in using computer hardware and software than those in group 1. That is, students with a high

**Table 4** *Results of the comparisons for online information searching strategies between group 1 and group 2*

| | **Group 1 (Subjects 2, 5)**** | **Group 2 (Subjects 1, 3, 4, 6, 7)** |
|---|---|---|
| *Information-searching strategies* | | |
| Control | Often frustrated | Smoothly |
| Disorientation | Usually occurred | Hardly occurred |
| Trial and error | Hesitate to perform | Easy to perform |
| Problem solving | Asking for help | Solving by self |
| Purposeful thinking | Rarely occurred | Frequently occurred |
| Selecting main idea | Read in all details on a web page | Quickly review headlines/hypertexts |
| Evaluating information | Tend to accept | Tend to criticize |
| Internet self-efficacy level | Low | High* |

* Except for subject 4, all subjects in group 2 had a high level of Internet self-efficacy.
** Since limited information was gathered from thinking aloud, subject 8 was excluded such that group 1 had only two subjects in this comparison.

level of ISE, in general, tended to use computers and the Internet more correctly and efficiently than those with a low ISE. For example, instead of activating a hyperlink with one click on the mouse, the low ISE subjects made a common mistake of trying to make a link by double-clicking a hyperlink. The disorientation rarely occurred with group 2 (mainly high ISE) students while it was frequently observed in group 1 (low ISE) students. It was found that the scripts like 'Oh, my God! I come back here again. It is so strange. I just cannot find … I don't know what to do now … I got lost' or 'Wow, what is this…How did I come here…Where should I go …' were found twice in 30 minutes (on average) for the low ISE students versus 0.25 times for the high ISE students.

For trial-and-error strategies, low ISE students were hesitant to use or create new approaches for searching when their approaches did not work; however, it was easy for high ISE students to perform this strategy. For instance, the high ISE subjects often typed in different keywords into the search engine; the low ISE subjects were reluctant. When encountering troubles, the high ISE students tended to solve problems by themselves, whereas the low ISE students tended to ask others for help. For example, when an error message came up on the screen, one of the low ISE students said 'Crash? Oh, my God! Is it crashed?' and immediately turned his head to the researcher for help.

It was also observed that, while searching, low ISE students hardly ever thought purposefully but high ISE students frequently did so. For example, statements like 'What is nuclear power… ok, let's go check… first' or 'ok, next we are going to search the advantages and disadvantages of nuclear power…' appeared clearly and frequently in the high ISE students' verbal scripts; however, they were rarely shown in the scripts of the low ISE students. When reading materials provided on screen, low ISE students tended to read all details in lines rather than look through headlines or hypertexts for selecting main ideas like high ISE students. For example, after typing in the keyword 'nuclear power' into local search engine 'Kimo' and pressing the return key, subject 1 (high ISE) said 'ok, now it starts searching… now here comes the result … and *let's choose related items to look*. Ok, let's go into Taiwan Power Company.' When subject 3 (high ISE) visited the website of Taiwan Power Company and came across a news page, she said 'let's take a look at this first, oh, there is so much news related to nuclear power … the first is … ok, because here are too many to see, let's just hold on … nothing we need here … let's go back … and back … now, let's take a look at nuclear system … ok, here is a brief introduction of nuclear power stations in Taiwan … let's look for more information here'. High ISE students tended to know the purpose of their searching clearly and to effectively select necessary information.

While evaluating information, low ISE students usually accepted it, rather than criticize its correctness or reliability, while high ISE students would question the position of the website or its information. For example, when subject 1 visited the website of the Taiwan Power Company, she stated that 'since this is the Taiwan Power Company website, what we can see are *only* the advantages of building nuclear power plants'. A similar situation was observed with subject 6. When visiting the Taiwan Power Company website, he suggested that 'this Web site should have a discussion board letting people display different thoughts whether we need nuclear power plants in Taiwan'. The questioning statement or suggestion like this was never found in low ISE students.

The above results revealed that subjects with high ISE tended to have better online information searching strategies and tended to learn better in a web-based learning task, except for subject 4. Although subject 4 self-reported herself as low Internet self-efficacy (shown in Table 1), she actually had strategic searching knowledge and skills (shown in Table 4) that led to successful searching and learning (shown in Table 2). This may be because limited experience is not good for building self-confidence for using the Internet. In this particular case, we hypothesized that some Internet novice learners may have been prepared for searching information on the WWW, but they may not have been aware of their own abilities.

Therefore, this study concluded that there is a possible interplay between students' Internet self-efficacy and their online information searching strategies. High ISE students tended to have better information searching strategies, and this may explain why the students with high ISE learned better than those with low ISE in a Web-based learning task (Table 3).

## DISCUSSION AND FURTHER RESEARCH

This study analysed a group of college students' information searching strategies and examined the role of Internet self-efficacy on these strategies. Based on the results, this study further proposed a framework for analysing Web-based searching strategies. It includes three domains: behavioural, procedural and metacognitive (Table 5). The behavioural domain, showing student basic manipulation and navigation on the Internet, includes the strategies of 'control' and 'disorientation.' The 'trial and error' and 'problem solving' strategies, showing student content-general searching approaches on the Internet, are categorized into the procedural domain. The metacognitive domain, indicating student self-control and higher order content-related cognitive activities on the Internet, contains 'purposeful thinking', 'selecting main idea' and 'evaluating information' strategies. This framework is in part similar to Hill's (1999) conceptual framework for understanding information searching in an open-ended information system.

**Table 5** *A framework for analysing online information searching strategies*

| Domain | Online information searching strategies |
|---|---|
| Behavioural | Control |
| | Disorientation |
| Procedural | Trial and error |
| | Problem solving |
| Metacognitive | Purposeful thinking |
| | Selecting main idea |
| | Evaluating information |

This framework may provide researchers with more understanding about the role of Internet self-efficacy in Web-based information searching and science learning. Internet self-efficacy is a user's perception about his/her own ability in using the Internet. Therefore, this perception is supposed to be clearly reflected in the user's behaviour, such as 'control' and 'disorientation'. Higher Internet self-efficacy may help students try better procedural strategies, for example, the use of 'trial-and-error' and 'problem solving by self' strategies. It is also suggested that higher Internet self-efficacy can facilitate higher order metacognitive skills, such as purposeful thinking, selecting main ideas and evaluating information that is provided on the Internet. In summary, higher Internet self-efficacy could enhance students' better behavioural, procedural and metacognitive strategies for searching information in a Web-based environment and, in turn, facilitate their learning in Web-based environments.

The next issue educators face is how to help students gain better online information searching strategies. This study suggests that an increase of Internet self-efficacy may facilitate a better utilization of these strategies. One major way of enhancing Internet self-efficacy is to increase Internet use. As shown in Table 1, students in this study who had more Internet experience tended to have higher Internet self-efficacy. The authors believe that the behavioural (e.g. control) and procedural (e.g. trial and error) strategies may be enhanced by increasing individuals' Internet experiences. However, we hypothesize that for some students the Web-based metacognitive strategies (e.g. purposeful thinking) may not be improved without explicitly teaching or training, similar to the need of strategic learning (Weinstein and Mayer, 1986) promoted in a traditional learning situation. The use of the Web-based metacognitive strategies may be a very important indicator for students' learning in a Web-based learning environment where much unselected information exists. Students need better metacognitive strategies to acquire relevant information and judge its usefulness. Therefore, teachers are encouraged to help students develop those strategies by direct demonstrations or strategy-embedded curriculum (Weinstein, 1994) before asking their students to learn in a Web-based learning environment.

Although the findings derived from this study are limited to a small sample size, research on Web-based searching and learning is still at an initial stage. Similar approaches with a small number of subjects were also shown in related studies (Hill, 1999; Oliver and Hannafin, 2000) concerning Web-based learning environments. Future research is suggested, using the initial framework provided in this study to further analyse students' information searching strategies in a larger scale and to examine the relationships and effects of these strategies on students' learning achievement in a Web-based learning environment.

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## BIOGRAPHICAL NOTES

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