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How University Students Evaluate Online Information about a Socio-scientific Issue and the Relationship with their Epistemic Beliefs

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ABSTRACT

The purpose of the study was to explore the judgment criteria used by university students for evaluating online information about a socio-scientific issue and the associations, if any, with their epistemic beliefs. The problem context was a socio-scientific issue concerning the impact of electromagnetic waves on human health. The participants were 36 university students, who were asked to read a news report, briefly state their thoughts, and then proceed to the web search activity in order to determine if their thoughts were legitimate. The students' search processes were recorded by web camera. After the search activity, all students were interviewed about the criteria used to determine the credibility of the online information. The students responded to the interview questions as they were watching their own web search processes. Epistemic beliefs were then assessed using questionnaires. A coding scheme was developed to analyze the students' oral responses. It was found that these university students determined the credibility of the online information mostly with reference to the richness and explanative power of argument, the presence of evidence, and the authority source of information. However, few of them went further to examine the validity of the evidence. Correlation analyses and ANOVA showed that the use of overall criteria for judging the online information was associated significantly with students' epistemic beliefs regarding authority. Meanwhile, the number of criteria used for justifying evidence was significantly associated with the students' beliefs about learning ability and justification in science.

Keywords

Web-based learning, Online information credibility, Epistemic beliefs, Media and science education

Introduction

In many work places, public areas, or at home, people rely on the World Wide Web to search for information that can help them solve problems and make decisions. Although online technology allows instant and easy access to knowledge and information, there are few constraints on what kinds of information should be posted on the Internet.

Consequently, web users need to develop effective judgment schemes to help them distinguish useful and credible online information. In the domain of science education, evaluating information is an essential part of a "scientific habit of mind," which emphasizes the critical and evaluative thinking about information as the evidence for any claim or theory. Nevertheless, until recent years, few studies in science education have paid attention to how students think and make judgments about the online information that concerns the application of science and technology. Thus, the purposes of this study were to explore the judgment schemes employed by university students for evaluating online information, and discuss the factors that might influence their evaluative behaviors.

Literature review

Criteria for judging online information

In the literature, a considerable amount of research regarding information searching can be found in the marketing, medical and health, and communication fields. In these studies, web search activities are linked to problem-solving and decision-making processes where the research questions are largely concerned with search strategies and consumer behaviors or characteristics (e.g., Darley, Blankson, & Juethge, 2010; Lin & Chan, 2009; Case, 2002). In

the last ten years, the World Wide Web has become a popular open source of information that can be easily accessed. However, since web information is often posted without proper screening, the issue about how web users evaluate the credibility of online information receives an increasing amount of attention from information researchers.

To justify online information, information researchers propose five key criteria—accuracy, authority, objectivity, currency, and coverage—as a guideline for information credibility (Metzger, 2007). However, empirical studies show that information seekers in general do not spend all of their mental efforts on evaluating the content of the online information. They determine its credibility largely by considering the characteristics of source, the quality of the data, the reputation of the source, the site's presentation, or sometimes only the surface features, depending on the search context (e.g., Eysenbach & Kohler, 2002; Fogg, Soohoo, Danielson, Marable, Stanford, & Trauber, 2003; Walthen & Burkell, 2002; Metzger, 2007).

In the context of learning, Metzger Flanagin, and Zwarun (2003), found that although college students used the Web extensively for searching for general and academic information, they seldom verified what they found. Kimsey and Cameron (2005) reported that college students lacked the critical thinking skills to evaluate the credibility of online information. Sundin and Francke (2009) showed that upper secondary school learners (around age 17 and 18) in a social science program displayed unsophisticated search skills, and also had a hard time evaluating the credibility of information they found on the Web. Julien and Barker (2009) also demonstrated a similar result with students in biology classes. Zuccala (2010) showed that when searching the online open access of research literature, users referred to science journalists as fact interpreters. Meanwhile, universities and scholars were considered more credible as information sources. Studies that have examined the practice of the five key criteria mentioned previously demonstrated that these criteria were not used frequently in students' responses, and on many occasions, only one or two were applied (Metzger, 2007; Julien & Barker, 2009). In sum, the studies reviewed above suggest that inadequate criterion systems are employed by learners for evaluating online information.

In the domain of science education, a major topic of discussion regarding Internet technology is how to incorporate the WWW source into instructional design. A popular instructional approach is the inclusion of online search activities as a part of the curriculum (Jonassen, Peck, & Wilson, 1999; Linn, Davis, & Bell, 2004; Relan & Gillani, 1997; Tsai, 2005). In general, it has been shown that such activities promote self-regulated learning and help learners to construct knowledge. More recently, to enhance search abilities and outcomes, a number of researchers have directed their attention to information needs, searching skills or strategies, and learner characteristics (Howard & Massanari, 2007; Jansen, Booth, & Smith, 2009; Liang & Tsai, 2010; Tsai, 2009; Hwang, Tsai, Tsai, & Tseng, 2008). Although the roles that the online search activities can play in promoting knowledge construction have been recognized by science educators, until recently few studies have examined how learners evaluate online information during a web search. A thorough examination of this issue can reveal students' reasoning modes, providing baseline information for curriculum design aimed at promoting evaluative and reflective thinking.

Although literature about information credibility has been accumulating in recent years, most available studies used self-report surveys or after-task interviews to assess students' evaluation performances. There are also studies confined to off-line environments (Mason, Boldrin, & Ariasi, 2010; Mason, Arisai, & Boldrin, 2011). The main problem of these methods is that they could not reflect the judgment criteria that students naturally employ during a particular search task. Thus, in this study, an attempt was made to address this issue. The first research question is: "During a naturalistic task, by what criteria did university students evaluate online information when they were exposed to a science-related issue that involves science and its application?"

Epistemic beliefs and its relevance to the evaluative intention

In the previous section, we argued that web users and learners at different levels tend to not employ legitimate schemes for evaluating online information. Information researchers have proposed a checklist training approach for improving evaluative ability. Basically, the approach emphasizes the one-by-one use of the five key criteria mentioned previously to guide the evaluation process (Metzger, 2007). Although the approach is useful, we found that users' information needs (motivations), ability, and the problem contexts mediate the evaluation results (Fritch & Cromwell, 2001; Walthen & Burkell, 2002; Dutta-Bergman, 2004; Metzger, 2007). Hence, we believe that an in-depth investigation of these factors will help clarify problems regarding how and why web users employ or do not employ criteria necessary for judging online information.

As mentioned, information research points out that user motivation and ability moderate the degree to which users evaluate online information. According to Metzger (2007), user motivation is related to personal or situational factors. Thus, other than the task demands, personal goals, values, and beliefs would determine whether an information searcher has found what he or she needs.

In this study, we propose an investigation of the belief construct. In particular, we are interested in the students' personal epistemic beliefs. Kitchener (1983) put forward that human cognition could be differentiated into three levels of activities at the cognitive, metacognitive, and epistemic levels. The epistemic level of cognitive activity involves personal reflections on or thinking about the epistemological assumptions about knowledge and knowing. Some researchers argue that personal beliefs about learning also constitute epistemological assumptions (Schommer, 1993). In the literature, different terminologies and models have been proposed to describe the above-mentioned personal reflections, such as personal epistemology, personal epistemological beliefs/perspectives, and epistemic beliefs. Though there are still disagreements among psychologists about the nature and definitions of personal epistemological assumptions, empirical studies have found that personal beliefs about knowledge, knowing, and learning seem to mediate thinking, decision-making and knowledge construction (Kitchener, 1983; King & Kitchener, 1994; Hofer & Pintrich, 1997; 2002; Schommer, 1993; Yang, 2005; Yang & Tsai, 2010).

In the context of web-based learning, many studies have found significant associations between epistemic beliefs and learning approaches as well as outcomes (Soloman, 2000; Hartley & Bendixen, 2001; Tsai, 2004; Yang & Tsai, 2008; Yang & Chang, 2009. Recent studies regarding web searching (Tsai, 2004; Tsai & Tsai, 2003) have indicated that learners' beliefs about the subject knowledge to be learned have a large effect on online search behaviors. Moreover, two recent studies found that college and high-school students were able to activate their epistemic beliefs when doing web searches about a controversial science issue (Mason, Boldrin, & Ariasi, 2010; Mason, Arisai, & Boldrin, 2011). Based on these studies, we believe that epistemic beliefs should also play a critical role in mediating the use of judgment criteria for evaluating online information. Thus, the second research question in the study is, "To what extent were the students' personal epistemic beliefs related to the judgment criteria used for evaluating the online information?"

Research method

Subjects

The participants of the study were 36 university students taking introductory courses in science education in two national universities in Taiwan. These students were aged from 20 to 25 and voluntarily took part in the study. Most of the subjects were science majors. Four were social science majors.

Assessments Interview with "meta-recall" technique for assessing the judgment criteria

To study the students' search behavior, we used an information search platform called Meta-Analyzer, developed by Hwang and colleges (2008), to record online search performance. This online platform was able to record the total search time, navigating time, and websites that the web searchers visited and explored. To assess their judgment criteria, we developed an interview protocol coupled with a "meta-recall" technique for data collection. The meta-recall was a concept inspired by a previous work conducted by Tsai (2001), who assessed students' cognitive structure using the interview procedure coupled with a meta-listening technique. In most studies that employ the interview method, subjects are usually asked to think aloud about what they did during an activity after the activity has been completed. Such a procedure suffers from the fact that subjects might not be able to track their actions precisely because of the high cognitive demand on their memory. To reduce the memory load, we used an online camera, WebCam, to record all the user actions displayed on the computer screen during the search task. After the search task, participants took part in interviews during which they were shown their own search processes and were asked to comment on the credibility of the websites that they had visited or skipped as displayed in their own search records. With the aid of this meta-recall technique, the students were brought back to the moments when they were checking the online information. We believed that the students' responses would therefore reflect more closely the actual criteria they used for evaluating the online information.

Tools for assessing epistemic beliefs

To explore different aspects of the students' epistemic cognition, two questionnaires of epistemological beliefs were employed in the study. One is the Revised Epistemology Questionnaire (REQ) modified from Schommer's Epistemology Questionnaire (EQ) (Schommer-Aikin, 2004). The other is the Scientific Epistemology Questionnaire (SEQ), originally developed by Conley et al. (2004). The REQ is a domain-general tool, while SEQ focuses specifically on the knowledge of science.

The 36-item REQ was adapted and reduced from the 63-item Schommer's Epistemological Questionnaire (EQ) for college students (Schommer, 1998. The REQ was developed by factor analysis with 350 university students in Taiwan. Four epistemological factors were abstracted from the factor analysis: (a) authority knowledge, with 6 items (Cronbach's $\alpha = 0.52$), (b) certain knowledge, with 10 items (Cronbach's $\alpha = 0.68$), (c) simple knowledge, with 11 items (Cronbach's $\alpha = 0.65$), and (d) Innate Ability with 9 items (Cronbach's $\alpha= 0.71$). According to Hofer and Pintrich (2002), the domain-general construct of personal epistemology suffers somewhat from ambiguous definitions and uncertainty about the core constituents. Therefore, the existing epistemology questionnaires developed based on the domain-general assumptions were usually not particularly reliable. However, Hatcher and Stepanski (1994) have claimed that, for social science studies, a Cronbach's alpha coefficient even as low as 0.55 can be recognized and accepted for statistical consideration. Accordingly, except for "authority knowledge," which was slightly below this requirement, the alpha values of these epistemic factors were statistically acceptable. The factor structure of REQ was similar to EBQ (32 items) developed by Quian and Alvermann (1995), who employed the previous version of EQ and the same analysis procedure.

The 26-item, five-point Likert-style SEQ questionnaire was developed by Conley and others (Conley, Pintrich, Vekiri, & Harrison, 2004). It also consists of four factors, namely source (five items, Cronbach's $\alpha = 0.82$); certainty (six items, Cronbach's $\alpha = 0.79$); development (six items, Cronbach's $\alpha = 0.66$); and justification (9 items, Cronbach's $\alpha = 0.76$). In brief, "source" concerns the belief in authority knowledge, "certainty" refers to the belief in the right answer, "development" measures the belief about science as an evolving and changing subject, and "justification" focuses on how individuals justify knowledge. The SEQ questionnaire was translated into Chinese and has been tested with Taiwanese samples (Liang & Tsai, 2010)

Procedure

The study involved activities of decision-making and online information searching. The problem context was a socio-scientific issue, namely "whether the electromagnetic waves (EMW) emitted by a cellular phone base station would cause cancer." Participants were first asked to write down their prior beliefs about whether EMWs are harmful to human health, and then two news reports from different standpoints regarding the effects of EMWs emitted from cellular base stations were given to the participants to read. They were then asked to write down their preferred position. Afterward, the students were asked to search freely on the World Wide Web in order to decide if their thoughts were legitimate. There was no time limit for their search because it was our intention to create a naturalistic task environment. Each student's search process was screen-captured by the WebCam software. Once the information search activity stopped, the interviews coupled with the meta-recall technique, as described in the instrument section, were conducted right away to probe the students' thoughts about the issue, and their criteria for judging the credibility of the information on the Web. The questionnaire surveys for epistemic beliefs were administered after the interviews.

Data analysis

Probing students' judgment criteria

As mentioned, to probe students' criteria for judging the online information, their whole online search processes were recorded and then shown during the interviews. The students were asked one webpage after another as they were displayed in their records to explain why they visited a particular website or stayed on some particular online information, and whether and why they thought the particular source or information was reliable. The interviews

were tape-recorded and afterward, all the responses were transcribed and analyzed according to the content analysis procedure.

To analyze the students' responses, we developed a coding scheme. Initially, the five key criteria identified in the literature regarding the credibility of the online information were considered, including accuracy, authority, objectivity, currency, and coverage (or scope) (Metzger, 2007). However, when analyzing the students' responses, we found that they actually displayed more complicated judgment systems for distinguishing the online information. Two aspects of information frequently appeared in the student responses, namely the content and the source of the information.

As far as content was concerned, the students proposed different concerns about the online information, such as whether the description was clearly and logically stated, whether the information was up-to-date (consistent with the currency criterion), whether the information was given without taking sides (aligned to the objectivity criterion), whether there were numerical data stated in the information, and so forth. As a matter of fact, the content criterion in many ways also overlapped with the coverage criterion, defined by the information research.

When speaking about the source of the information, many students would check whether the information was from authority sources including professional organizations, books, science magazines (the authority criterion), or other sources open to the public. In addition to the content and source categories, quite a few students talked about whether the online information was consistent with their own experiences, beliefs, and prior understandings.

Consequently, a coding scheme for assessing the online judgment criterion was constructed. Table 1 shows the main evaluation categories (indicated by "aspect"), the associated requirement of each aspect, the major criterion, and examples of student responses. Five students' responses were randomly selected for the inter-coder agreement analysis after the final coding scheme was established. The agreement was higher than 93%. The slight difference was discussed and reconciled. A single coder then did the rest of the coding analysis.

Table 1. The categories, aspects, major criteria and student responses for evaluating the online information

Aspect	Requirement	Major criteria	Student responses (examples)
Content	Argument	Richness	• It provided detailed information about the standards for the emission of electromagnetic waves (such as boundary conditions).
		Power of explanation	• The information contained explanative information. • It explained the cause and effects.
		Clear scope	• It provided well-defined definitions and conditions of the damage.
		Clear reference	• It provided background information of who posted the information (such as occupation and academic background).
		Objectivity	• It provided information of both sides.
		Logical and structured statement	• The arguments were logically and clearly stated.
	Evidence	Controlled study	• There was a controlled experiment/study.
		Empirical data	• It provided numerical data in the text.
		Repetition	• It was only a one-time human experiment. More experiments are needed.
	Format	Science report	• It was a medical report.
		Descriptions of real cases	• They showed real incidents.
Source	Organization	Authority	• The information was provided by some research organization. • It was from a global group or organization.
	Expert	Authority	• The information was provided by a scientist. • It was posted by people with a proper background.
	Website	Public accessibility	• It was from a wiki.

		Reliability	• English sites are more reliable.
	Document	Authority	• It was a book chapter. • It was from a thesis.
Personal domain		Belief/theory	• It was consistent with what I believe.
		Prior understanding	• It was consistent with my understanding.

Analyzing personal epistemic perspectives and their associations with the use of judgment criteria

As mentioned in the instrument section, two questionnaires (REQ and SEQ) were used to assess the students' epistemic perspectives in both general and science domains. Both REQ and SEV have four factors. Thus, the mean scores of each factor were calculated and compared via descriptive and correlation analyses. Meanwhile, to cross-analyze the students' judgment criteria and their epistemic beliefs, correlation analyses and one-way ANOVA were performed.

Result

The overall web search

According to the meta-analyzer records, the average time of a web search was 14.76 minutes (*SD* = 7.75) and the mean number of visited web sites was 10.09 (*SD* = 6.44). Among the visited sites, non-science-related websites were visited more often (mean = 8.49, *SD* = 5.51) than science-related sites (mean = 1.60, *SD* = 1.59).

The criteria used for judging the online information

The coding result of the students' judgment criteria is shown in Figures 1 to 4. Basically, as Table 1 reveals, three aspects of online information, namely content, source, and personal aspects, could be extracted from the participants' responses. In the content aspect, the web searchers would consider three requirements. The first is the argument requirement: "Were the arguments well presented?" The second is the evidence requirement: "Was there any empirical evidence?" The third was the format requirement: "What types of online information were more reliable?"

To satisfy the argument requirement, whether the information provided enough details and varieties of viewpoint (richness), and whether the information contained sufficient explanations of the cause and effects (explanative power) were the two major criteria frequently mentioned by the participants (higher than 30%). Some students (about 25%) paid attention to whether the information was well organized and logically stated, and whether the conditions for the facts to occur and the extent of the effects were explicitly described (scope). However, only about 22% of participants were concerned with whether the information was objectively expressed without taking sides (objectivity), and even fewer students (about 10%) reflected on whether the information was up-to-date (currency). The coding result is shown in Figure 1.

Since the problem context of the study was science-related, most students expressed the need for evidence. As presented in Figure 2 for the evidence request, most participants considered the presence of empirical data (mentioned by 66.7% of the participants). Nevertheless, less than half of the students (about 42%) went further to check if the data came from repeated studies or had been mentioned many times in other online sources. About 30% of the students mentioned that related claims should be drawn based on controlled studies. Some participants (22%) expected to see descriptions of how the studies were done. In short, for some university students, empirical data alone could not guarantee the validity of the online information. How the data were obtained and tested were also critical points to be considered. However, the percentage distributions showed that most students did not exercise multiple criteria to justify evidence.

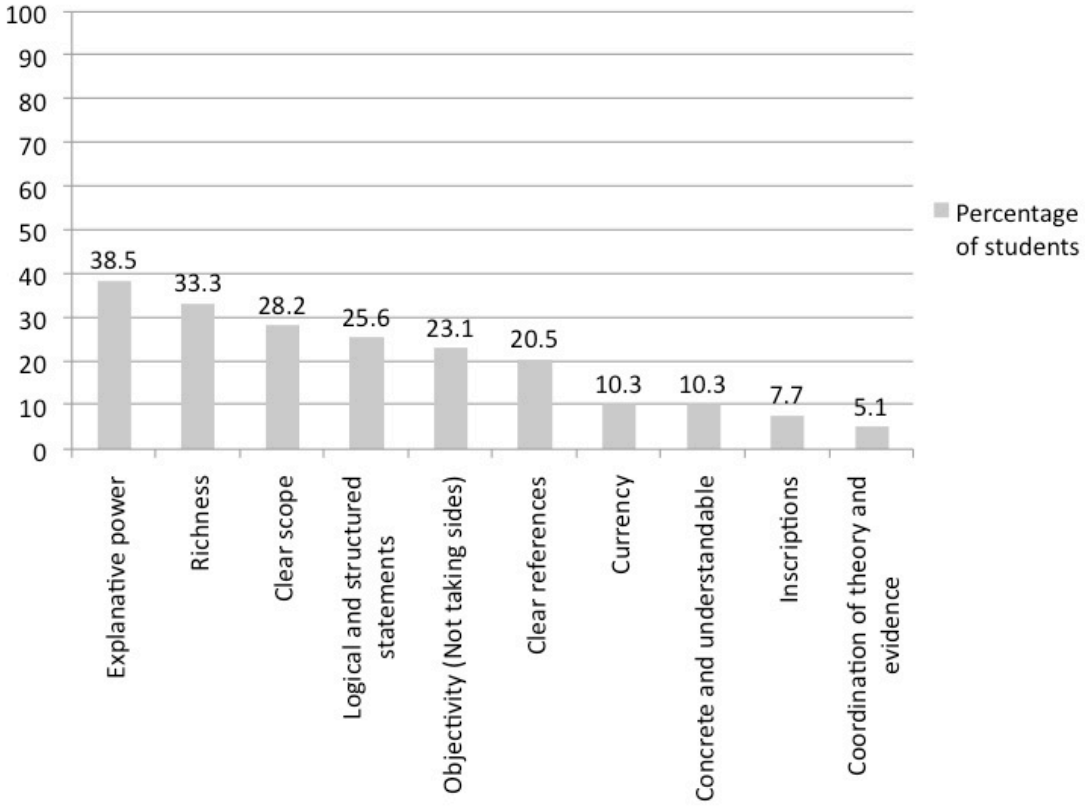

Figure 1. Percentage of students per argument criterion

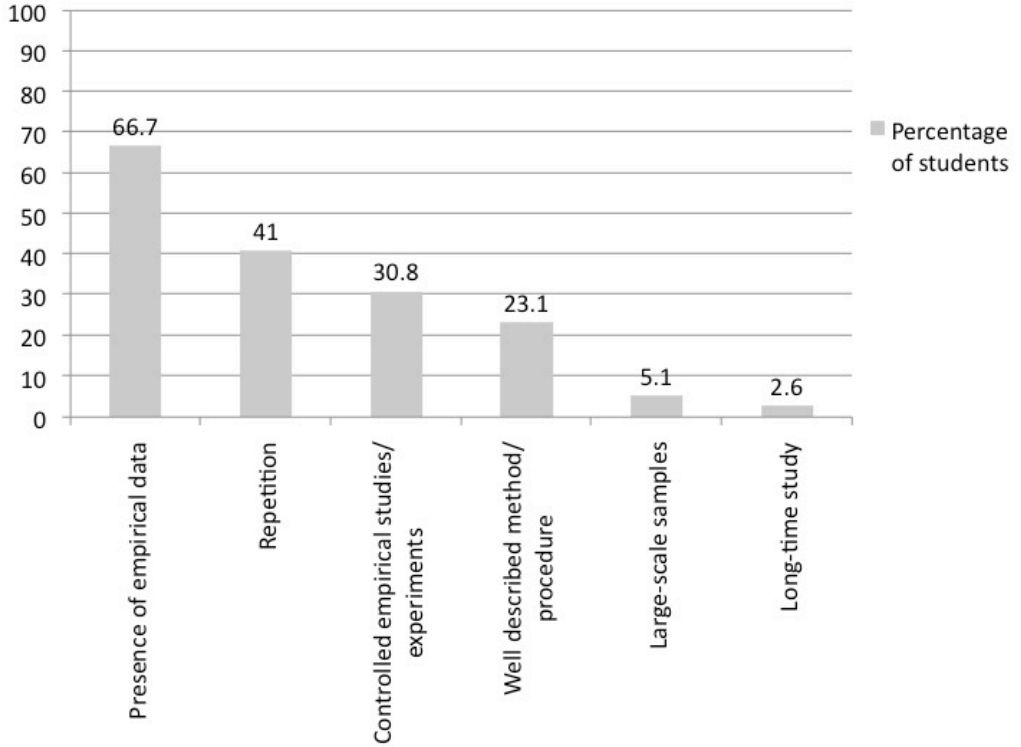

Figure 2. Percentage of students per evidence criterion

The frequency analysis of the criteria for "evidence" is shown in Table 3. We found that the majority of participants (about 86%) recognized the need for scientific evidence. Among these students, most were able to pinpoint one criterion, but only 36% of students went further to question the quality of the evidence.

Table 3. The numbers and percentages of "evidence" criteria

Number of criteria	Number of subjects	Percentage
0	5	13.9
1	18	50.0
2	8	22.2
3	4	11.1
5	1	2.8
Total	36	100.0

Furthermore, as indicated in the "format" requirement (see Figure 3), about 39% of the participants mentioned that the information would be more reliable if it was a science report or a description of real incidents.

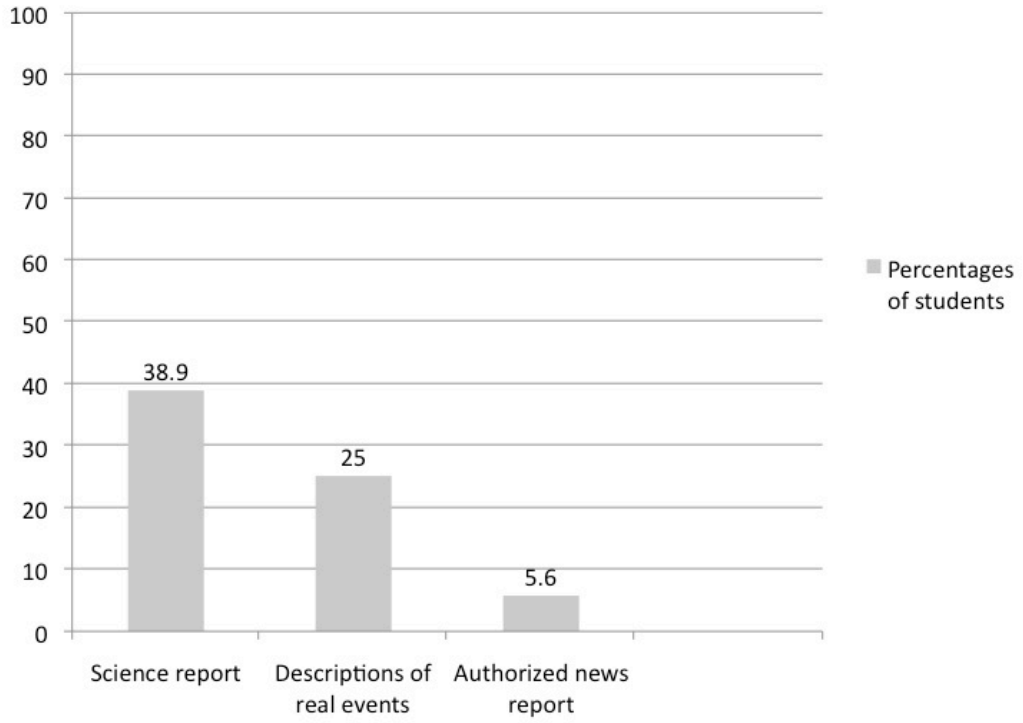

Figure 3. Percentage of students per format criterion

From the students' responses, we found that "source" was a vital aspect for them to look at. In general, as shown in Figure 4, information that came from authority (or professional) sources, such as professional organizations or expert figures, was considered to be trustworthy. In addition, if the information came from online sources that were open to the public, the degree of legitimacy might be increased. Finally, it was found that over 55% of students tended to take serious consideration of their own beliefs or understandings about the EMW issue when making judgments.

Students' uses of these criteria in terms of mean numbers are displayed in Table 4. The mean number of overall criteria (referred to as CRITERIA in Table 4) used in judging the online information was 6.42. On average, the students recognized two aspects of the online information, and they were able to pinpoint four judgment requests. Meanwhile, they considered approximately four criteria on average in the content aspect and more than one in the source aspect. As for the personal aspect, over half of the subjects (55.6%) mentioned either their personal beliefs or prior understanding of the issue. The mean numbers of criteria of the two most frequently mentioned requirements in the content aspect are also listed in Table 4. They are "argument" and "evidence." As noted, our subjects used

approximately two criteria to examine the arguments presented in the online information, but only 1.42 to evaluate evidence.

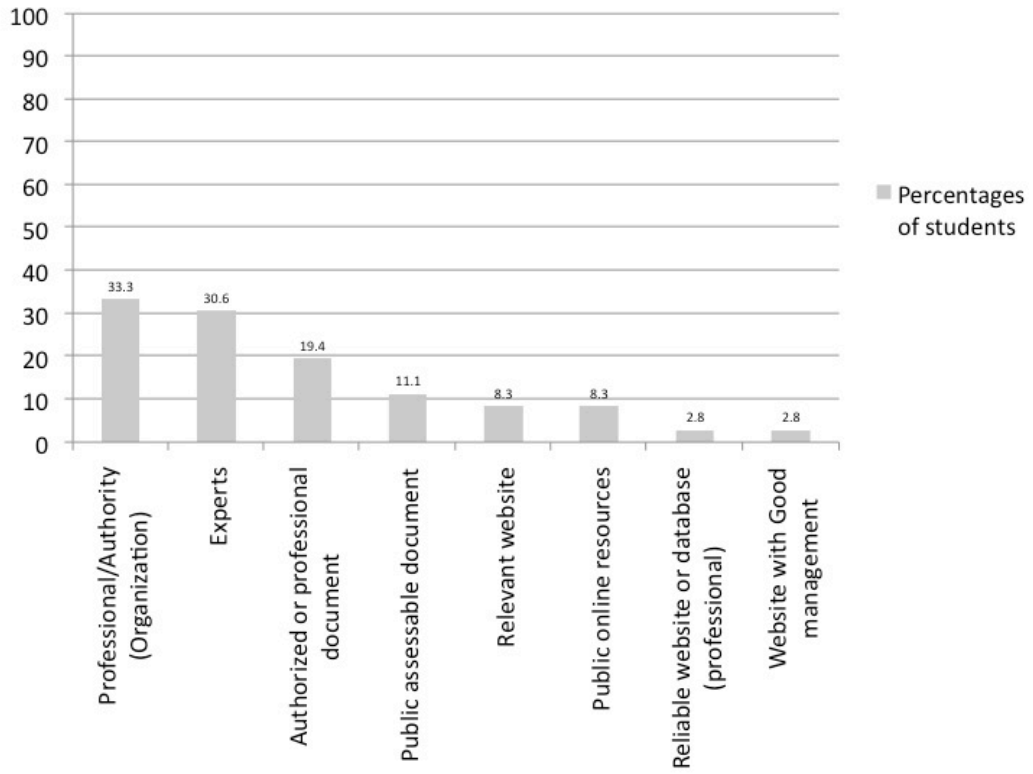

Figure 4. Percentage of students per format criterion

Table 4. The numbers of judgment criteria used for judging the online information

Criteria category	Minimum	Maximum	Mean	*SD*
ASPECT	1	3	2.31	0.62
REQUIREMENT	2	8	4.25	1.25
SOURCE[1]	0	5	1.50	1.28
CONTENT[1]	1	8	4.36	1.71
PERSONAL[1]	0	1	0.53	0.51
ARGUMENT[2]	0	5	2.11	1.26
EVIDENCE[2]	0	5	1.42	1.05
CRITERIA	3	12	6.42	2.38

Note: 1 = components of "aspects"; 2 = requirements of "content"

Students' epistemic beliefs

As mentioned above, two questionnaires, REQ and SEQ, were administered to assess the students' epistemic beliefs. All participants (n = 36) completed the REQ survey, but only 32 completed the SEQ. Tables 5 and 6 present the descriptive statistics for the REQ and SEQ results. According to Table 5, the university students in this study tended to agree that knowledge, in a general sense, comes from authority (mean = 3.04,), but they thought more or less that knowledge is uncertain (mean = 2.77). On the other hand, when asked about scientific knowledge (as Table 6 shows), they seemed to have doubts about authority source (mean = 2.45) and believed to some extent that scientific knowledge is uncertain (mean = 2.65). Meanwhile, they agreed that scientific knowledge undergoes development and justification.

Table 5. The factor structure and scores of REQ (on a five-point Likert scale, $n = 36$)

Factor	Item	Reliability	Mean (*SD*)
AUTHORITY KNOWLEDGE (AK)	6	0.52	3.04 (0.51)
CERTAIN KNOWLEDGE (CK)	10	0.68	2.77 (0.53)
INNATE ABILITY (IA)	9	0.65	2.22 (0.42)
SIMPLE KNOWLEDGE (SK)	11	0.71	2.04 (0.53)

Table 6. The factor structure and scores of SEQ (on a five-point Likert scale, $n = 32$)

Factor	Item	Reliability	Mean (*SD*)
SOURCE (S)	5	0.81	2.45 (0.61)
CERTAINTY (C)	6	0.79	2.65 (0.72)
DEVELOPMENT (D)	6	0.58	4.42 (0.49)
JUSTIFICATION (J)	9	0.66	4.23 (0.42)

Table 7 reveals the associations between REQ and SEQ. As the table displays, beliefs in authority knowledge and certain knowledge in general (AK and CK) were significantly correlated to beliefs in authority sources and certain knowledge in science (S and C). Belief in the simple structure of knowledge in general (SK) was negatively correlated with beliefs in development and justification in science (D and J) to a rather high degree. In addition, belief in innate ability was moderately correlated with belief in certain knowledge in science and negatively correlated with belief in development and justification in science. In sum, epistemic beliefs regarding knowledge and learning in general were associated from moderate to high degrees with beliefs about the nature of scientific knowledge and the construction of scientific knowledge.

Table 7. Correlations between REQ and SEQ factors ($n = 32$)

	S	C	D	J
AK	0.43*	0.52**	−0.17	0.07
CK	0.34(*)	0.35*	−0.12	0.04
IA	0.21	0.38*	−0.35*	−0.31(*)
SK	−0.17	0.12	−0.47**	−0.63**

*$p < 0.05$; ** $p < 0.01$; (*) $p < 0.1$

Associations between the use of judgment criteria and epistemic beliefs

To find out the associations, if any, between the use of judgment criteria and epistemic beliefs, we conducted a correlation analysis. According to the Spearman's rho analysis, the factor of authority knowledge in REQ was significantly correlated with the number of argument criteria ($r = -0.39$, $p < 0.05$) and approximately correlated with the total number of criteria used in judgment ($r = -0.26$, $p < 0.1$). As for SEQ, the factor of authority source was approximately associated with the number of argument criteria in the content aspect ($r = -0.32$, $p < 0.1$) and the number of overall criteria ($r = -0.27$, $p < 0.1$). In sum, the correlation analyses revealed that the number of criteria used in judging online information seemed to be more apparent in relation with beliefs in authority. It seems that the more students believed in authority, the fewer criteria they would apply to examine the content of online information.

In addition to the correlation analysis, an in-depth investigation was carried out by the one-way ANOVA. The criterion categories in Table 3 were included in the analysis. To perform one-way ANOVA, we grouped the students into three levels indicating high (H), mean (M), and low (L) criterion usage. The mean numbers of the criteria, as shown in Table 3, plus or minus 0.5 standard deviation, were used as the grouping standards. Since the number in each usage level was uneven, the test of homogeneity of variance was performed to examine the equality of the group variances. The significant findings reported here survived the test.

The ANOVA result showed that among these criterion categories, usage levels of the argument, and evidence criteria in the content aspects were statistically associated with the students' epistemic beliefs. Tables 8 and 9 demonstrate the findings.

Table 8. One-way ANOVA for epistemic beliefs and the use of evidence criteria

Epistemic beliefs	Usage level[1]	*N*	Mean	*SD*	ANOVA[2] *F*	ANOVA[2] Post-hoc analysis
REQ Innate	L	5	2.00	0.29	3.57*	Level 2 > Level 3(*)
	M	18	2.36	0.43		
	H	13	2.03	0.33		
REQ Simple	L	5	1.64	0.35	3.00(*)	Level 2 > Level 1(*)
	M	18	2.23	0.59		
	H	13	1.98	0.41		
SEQ Development	L	4	4.92	0.10	3.02(*)	Level 1 > Level 2(*)
	M	15	4.28	0.42		
	H	13	4.40	0.56		
SEQ Justification	L	4	4.61	0.14	3.38*	Level 1 > Level 2 (*)
	M	15	4.07	0.42		
	H	13	4.32	0.40		

Notes:
1. Level L—no criterion used; level M—one criterion used; level H—more than one criterion used
2. * $p < 0.05$; (*) $p < 0.1$

Table 9. One-way ANOVA for epistemic beliefs and the use of the argument criteria

Epistemic beliefs	Usage level[1]	*N*	Mean	*SD*	ANOVA[2] *F*	ANOVA[2] Post-hoc analysis
REQ Authority	L	11	3.26	0.29	4.34*	Level 1 > Level 3*
	M	12	3.14	0.43		Level 2 > Level 3 (*)
	H	13	2.74	0.33		
SEQ Authority source	L	9	2.76	0.88	2.40(*)	
	M	10	2.40	0.41		
	H	13	2.22	0.37		

Notes:
1. Level L—one criterion used; level M—two criteria used; level H—more than two criteria used
2. * $p < 0.05$; (*) $p < 0.1$

The post-hoc analyses displayed in Table 8 show that those in the high-usage level (that is, those who used more than one evidence criterion) to evaluate the online information tended to believe less in their innate ability. However, those who did not mention any evidence criteria (low usage) seemed to hold a stronger idea that knowledge is not just simple, piecemeal facts but has complicated structure and that scientific knowledge undergoes development and justification. As far as the use of argument criteria was concerned, the post-hoc analyses in Table 9 indicate that more criteria were used by students who believed less in authority.

Discussion

Use of judgment criteria

Our study demonstrates that when judging online information that involves scientific investigations, these university students activated complicated judgment systems to evaluate the credibility of the information. According to the content analysis, the students in this study paid rather high attention to the content and source aspects of the information. They examined the richness and explanative power of the arguments, required empirical evidence, and checked if the information came from authority sources. With respect to the five key criteria proposed by the information researchers, students in this study considered more the coverage and authority criteria but less the accuracy, objectivity, and currency criteria. This result was consistent with previous findings (e.g., Metzger, 2007; Julien & Barker, 2009). From the students' responses, it was also evident that they had employed various criteria beyond the scope of the five main criteria. These findings imply a lack of understanding of the information credibility of adult learners.

In the process of scientific argumentation, the inclusion of evidence is crucial for making a sound argument. However, while the evidence request was important for verifying the scientific claims, it is not explicitly included in the literature of information credibility. Even though, by definition, the evidence criterion might conceptually overlap the accuracy criterion, the former specifies the process of science. Hence, it is suggested that the evidence request, including the presence of empirical data and quality of evidence, should be regarded as a key criterion for the credibility of online information that involves scientific arguments. In this study, we found that most participants recognized the need for scientific evidence, but less than half went further to question the quality of the evidence. Such a finding echoes previous findings that even adults do not understand the role evidence plays in scientific argumentation (Kuhn, 1991).

The associations between students' epistemic beliefs and evaluation behaviors

In this study, we also investigated a psychological factor that theoretically motivates the practice of judgment criteria, that is, the students' epistemic beliefs. One domain-general (REQ) and one domain-specific (SEQ) questionnaire were used to assess their beliefs. The correlation analysis found medium to high degrees of association between some of the factor scores of the two instruments, which indicate an overlap of the epistemic conceptions assessed by the two instruments.

The relationship between the students' epistemic beliefs and their use of judgment criteria was examined by correlation analysis and ANOVA. The correlation analyses showed that the more criteria used to examine the content of arguments, the less belief in authority the student had. The result of the one-way ANOVA also confirmed this finding. On the other hand, one-way ANOVA found that the use of criteria for verifying the presence and quality of evidence seemed to interact with beliefs in innate ability, the simplicity of knowledge, and development in science and justification in science. Further ad hoc analyses demonstrated that while students who exercised more evidence-based criteria tended to hold lower beliefs in their innate ability, some with lower scores in simple knowledge (indicating that they held the idea that knowledge is rather complex) mentioned no evidence at all. Similarly, students who gave higher scores for their beliefs about development and justification in science might not even recognize the role of evidence.

The above findings suggest complicated interactions between the use of evidence-related criteria and students' epistemic beliefs regarding learning ability, knowledge structure, and the construction of scientific knowledge. Although many students displayed advanced epistemic beliefs, not all of them recognized that evidence needs to be justified. In other words, even when students have seemingly developed advanced epistemic beliefs, they might still lack an in-depth understanding of the role of evidence in the development of scientific knowledge. The participants of this study could have regarded evidence as a part of scientific knowledge, and consequently found no need to justify it. This finding is consistent with previous studies showing that adults and adolescents tend to lack a proper understanding of the nature of evidence and theory (e.g., Kuhn, 1991; Yang, 2005). However, it should be noted that we conducted the correlation analysis and ANOVA in an attempt to probe possible relationships. Future studies should include large-scale samples or experimental designs to study in-depth the role of epistemic beliefs in the evaluation process.

Educational implications

As discussed above, the participants of this study were able to practise complicated schemes to evaluate online information, but the schemes deviated from what information researchers have defined for information credibility. These findings suggest a need for training or learning activities aimed at promoting the understanding of information credibility. In particular, emphasis should be placed on accuracy, objectivity, and currency. As suggested by information researchers, a checklist approach based on the "big five" criteria (Metzger, 2007) would be a good way to focus web users' attention on the critical aspects of online information. Noticeably, considering the nature of the issue discussed in this study, which involved consideration of scientific information, the validity of evidence should also be included as a major criterion for information credibility. Accordingly, we recommend that the design of the training program for information credibility should take into consideration the problem context and the nature of information to be discussed.

In this study, we show that the use of criteria is associated with personal epistemic beliefs. This finding suggests that students' practices of judgment schemes could not be solely explained by unfamiliarity with information credibility. A thorough exploration of the nature of knowledge and the process of knowledge construction is critical for enhancing learners' intention to use the essential criteria mentioned in the study. It is thus recommended that, prior to the training program for information credibility, trainees should be given opportunities to reflect on their own personal views about the nature of knowledge and knowing. In this way, both trainer and trainees will have a chance to reach an agreement on the credibility criteria.

Another fact revealed by the study is that, after years of science education, university students majoring in science might still hold naïve views about scientific evidence. This finding is a warning for science educators because it implies that scientific knowledge could have still been portrayed in schools as an end product without the process of justification (Duschl, 1990). While there are many reform efforts to be made, teachers can make use of online resources to design curricula that emphasize scientific argumentation that allows learners to experience the process of knowledge construction in science (Duschl & Osborne, 2002). Course activities that include the searching and evaluation of online information related to controversial science issues or socio-scientific issues, such as the one presented in this study, could be an effective way to bring about discussions on the development of science and scientific knowledge.

Limitations and the future development of the study

Although by way of the qualitative and quantitative analyses, this study made an attempt to reveal the criterion system employed by university students for evaluating online information, and how the use of criteria might be affected by students' epistemic beliefs, generalization of the study results should be made with caution. First, this study involved 36 university students who were mostly majoring in science. Considering the optimum requirements of quantitative analysis, the small number of subjects involved and the lack of students with non-science backgrounds would reduce the power of generalization. In terms of future research, a thorough and large-scale investigation with students from various academic backgrounds is recommended. Such a large-scale study will allow a further discussion of the prior knowledge effect. In addition, given that the current study analyzed students' evaluative criteria one by one, it is also expected that a large-scale study that applies cluster analysis may further reveal whether certain criteria are activated together. Second, since the study was mainly explorative in nature, whether a learning or training process can effectively change students' evaluative behavior as claimed in the previous section remains an open question. Thus, in the future, it is necessary to conduct experimental studies that aim to examine whether students' evaluation behaviors can be changed or guided by the instructional treatments.

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References

Case, D. O. (2002). *Looking for information: A survey of research on information seeking, needs, & behavior.* San Diego, CA: Academic Press.

Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology, 29(2)*, 186–204.

Duschl, R. (1990). *Restructuring science education*. NY, NY: Teachers College Press.

Duschl, R., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education, 38*(1), 39–72.

Darley, W. K., Blankson, C., & Juethge, D. J. (2010). Toward an integrated framework for online consumer behavior and decision making process: A review. *Psychology & Marketing*, *27*(2), 94–116.

Dutta-Bergman, M. J. (2004). The impact of completeness and web use motivation on the credibility of e-health information. *Journal of Communication, 54*(2), 253–269.

Eysenbach, G., & Kohler, C. (2002). How do consumers search for and appraise health information on the World Wide Web? Qualitative study using focus groups, usability tests, and in-depth interviews. *British Medical Journal, 324*(7337), 573–577.

Fogg, B. J., Soohoo, C., Danielson, D. R., Marable, L., Stanford, J., & Trauber, E. R. (2003, June). *How do users evaluate the credibility of web sites? A study with over 2,500 participants*. Paper presented at the Proceedings of the 2003 Conference on Designing for User Experiences, San Francisco, CA. Retrieved March 17, 2013, from http://portal.acm.org/citation.cfm?doid=997078.997097

Fritch, J. W., & Cromwell, R. L. (2001). Evaluating internet resources: Identity, affiliation, and cognitive authority in a networked world. *Journal of the American Society for Information Science and Technology, 52*(6), 499–507.

Hartley, K., & Bendixen, L. D. (2001). Educational research in the Internet age: Examining the role of individual characteristics. *Educational Researcher, 30*(9), 22–26.

Hatcher, L., & Stepanski, E. J. (1994). *A step-by-step approach to using the SAS system for univariate and multivariate statistics.* Cary, NC: SAS Institute.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*(1), 88–140.

Hofer, B. K., & Pintrich, P. R. (Eds.). (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, New Jersey: Lawrence Erlbaum Associates

Howard, P. N., & Massanari, A. (2007). Learning to search and searching to learn: Income, education, and experience online. *Journal of Computer-Mediated Communication, 12*(3), Art. 5.

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

Jansen, B. J., Booth, D., & Smith, B. (2009). Using the taxonomy of cognitive learning to model online search. *Information Processing & management, 45*(6), 643–663.

Jonassen, D. H., Peck, K. L., & Wilson, B. G. (1999). *Learning with technology: A constructivist perspective*. New Jersey: Merrill.

Julien, H., & Barker , S. (2009). How high-school students find and evaluate scientific information: A basis for information literacy skills development. *Library & Information Science Research, 31*(1), 12–17.

Kimsey, M. B., & Cameron, S. I. (2005). Teaching and assessing information literacy in a geography program. *Journal of Geography, 104*(1), 17–23.

King, P. M., & Kitchener, K. S. (1994). The development of reflective thinking in the college years: The mixed results. *New Directions for Higher Education, 1993*(84), 25–42.

Kitchener, K. S. (1983). Cognition, metacognition and epistemic cognition. *Human Development, 26*(4), 222–232.

Kuhn (1991). *The skill of argument*. Cambridge: Cambridge University Press.

Liang, J. C., & Tsai, C.–C. (2010). Relational analysis of college science-major students' epistemological beliefs toward science and conceptions of learning science. *International Journal of Science Education, 32*(17), 2273–2289.

Lin, J., & Chan, H. C. (2009). Understanding the beliefs and intentions in search and purchase functions in an e-commerce website. *IEEE Transactions on Engineering Management*, *56*(1), 106–114.

Linn, M. C., Davis, E. A., & Bell, P. (2004). *Internet environments for science education.* Mahwah, NJ: Lawrence Erlbaum Associates.

Mason, L., Boldrin, A., & Ariasi, N. (2010). Searching the web to learn about a controversial topic: Are students epistemically active? *Instructional Science, 38*(6), 607–633.

Mason, L., Ariasi, N., & Boldrin, A. (2011). Epistemic beliefs in action: Spontaneous reflections about knowledge and knowing during online information searching and their influence on learning. *Learning and Instruction, 21*(1), 137–151.

Metzger, M. J., Flanagin, A. J., & Zwarun, L. (2003). Student Internet use, perceptions of information credibility, and verification behavior. *Computers & Education, 41*(3), 271–290.

Metzger, M. J. (2007). Making sense of credibility on the Web: Models for evaluating online information and recommendations for future research. *Journal of the American Society for Information Science and Technology, 58*(13), 2078–2091.

Quian, G., & Alvermann, D. (1995). Role of epistemological beliefs and learned helplessness in secondary school students. *Journal of Educational Psychology, 87*(2), 282–292.

Relan A., & Gillani, B. B. (1997). Web-based instruction and traditional classroom: Similarities and differences. In B. H. Khan (ed.), *Web-based instruction* (pp. 41–46). Englewood Cliffs, NJ: Educational Technology Productions.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology, 85*(3), 406–411.

Schommer, M. (1998). The influence of age and education on epistemological beliefs. *The British Journal of Educational Psychology*, *68*(4), 551-562.

Solomon D. L. (2000). Toward a post-modern agenda in instructional technology. *Educational Technology Research and Development, 48*(4), 5–20.

Sundin, O., & Francke, H. (2009). In search of credibility: Pupils' information practices in learning environments. *Information Research: An International Electronic Journal, 14*(4)*,* 418. Retrieved from http://informationr.net/ir/14-4/paper418.html

Tsai, C.-C. (2001). Probing students' cognitive structures in science: The use of a flow map method coupled with a meta-listening technique. *Studies in Educational Evaluation*, 27, 257-268

Tsai, C.-C. (2004). Information commitments in web-based learning environments. *Innovations in Education and Teaching International, 41*(4), 105-112.

Tsai, M. J., & Tsai, C.-C. (2003). Information searching strategies in web-based science learning: The role of Internet self-efficacy. *Innovations in Education and Teaching International, 40*(1)*,* 43–50.

Tsai, C. C. (2005). Preferences toward Internet-based learning environments: High school students' perspectives for science learning. *Educational Technology & Society, 8*(2), 203–312.

Tsai, M. J. (2009). Online information searching strategy inventory (OISSI): A quick version and a complete version. *Computers & Education, 53*(2), 473–483.

Walthen, C. N., & Burkell, J. (2002). Believe it or not: Factors influencing credibility on the Web. *Journal of the American Society for Information Science and Technology, 53*(2), 134–144.

Yang, F. Y., & Chang, C. C. (2009). Examining high-school students' preferences toward learning environments, personal beliefs and concept learning in web-based contexts. *Computers & Education, 52*(4), 848–857.

Yang, F. Y. (2005). Student views concerning evidence and the expert in reasoning a socio-scientific issue and personal epistemology. *Educational Studies, 31*(1), 65–84.

Yang, F. Y., & Tsai, C. C. (2010). Reasoning on the science-related uncertain issues and epistemological perspectives among children. *Instructional Science, 38*(4), 325–354.

Zuccala, A. (2010). Open access and civic scientific information literacy. *Information Research: An Informational Electronic Journal, 15*(1). Retrieved from the Information Research website: http://informationr.net/ir/15-1/paper426.html