Computers & Education 72 (2014) 220–230

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

A creative thinking approach to enhancing the web-based problem solving performance of university students

Fan-Ray Kuo [a], Nian-Shing Chen [a], Gwo-Jen Hwang [b,*]

[a] Department of Information Management, National Sun Yat-Sen University, 70, Lienhai Rd., Kaohsiung, 80424, Taiwan
[b] Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, 43, Sec. 4, Keelung Rd., Taipei, 106, Taiwan

ARTICLE INFO

Article history:
Received 18 June 2013
Received in revised form
18 October 2013
Accepted 6 November 2013

Keywords:
Teaching/learning strategies
Post-secondary education
Interactive learning environments
Web-based learning

ABSTRACT

Along with the advancement of information and communication technology, researchers have pointed out the necessity and challenges of developing effective instructional strategies to enhance students' web-based problem-solving performance, which refers to the ability of investigating a series of related problems via searching for, abstracting and summarizing information on the web. In this study, a creative thinking strategy is proposed to cope with this problem. Moreover, an experiment was conducted on 80 freshmen from two classes of a university to evaluate the effectiveness of the proposed approach. The experimental results show that the proposed approach improved the students' web-based problem solving performance in comparison with the conventional approach in terms of "problem finding" and "idea finding." Moreover, it was found that the proposed approach could improve the "fact finding" performance of the students with intuitive-type cognitive style. Accordingly, some implications and suggestions are given for educators who attempt to conduct web-based problem-solving activity.

1. Introduction

Nowadays, society is changing in the face of the global information explosion; thus, it is important for schools to cultivate students' abilities of seeking, identifying and applying information on the web for investigating specified issues (Bilal, 2002; Thompson, Martin, Richards, & Branson, 2003; Tsai & Shen, 2009). Such learning activities referring to answering a series of questions related to a particular issue via comprehending the issue and questions, searching for web information, selecting and abstracting the searched information, and summarizing the information to answer the questions, have been called web-based problem solving by researchers (Kuo, Hwang, & Lee, 2012). Scholars have emphasized the need for conducting web-based learning activities in universities to help students learn to investigate important issues using web resources (Kear & Heap, 2007; Siragusa, Dixon, & Dixon, 2007). It is expected that students can develop systematic problem solving approaches for correctly analyzing the issues to be investigated, evaluating the correctness of the obtained information, and summarizing their findings (Hwang & Kuo, 2011; Tsai & Tsai, 2013).

However, researchers have found that most university students usually deal with web information-seeking tasks by accessing a small quantity of network resources without evaluating the correctness and quality of the acquired information; nor do they made proper abstractions and interpretations when using the information (Bruno, 1987; Clerehan, Kett, Gedge, & Tuovinen, 2003; Hwang & Kuo, 2011; Tseng, Hwang, Tsai, & Tsai, 2009). Therefore, it is important to improve students' web information-seeking and applied abilities, including identifying problems as well as searching for, analyzing, evaluating, interpreting, and utilizing information obtained from the web (Dickey, 2007; Eisenberg & Berkowitz, 2000; Lee, 2010; Liu, Cheng, & Huang, 2011; Scherer & Tiemann, 2012).

The strategy of Creative Problem Solving proposed by Treffinger and Isaksen (1992) is such an approach that engages students and teachers in the process of solving open-ended questions via a systematic thinking method (Abell, 1990; Ackerman & Karen, 2005; Ladbrook & Probert, 2011). It provides step-by-step guidance or scaffolding to help students identify the core of the target problem via knowledge sharing, peer interactions, conflict resolution, and information summarization. Previous research concerning applications of Creative Problem Solving strategy were proven to be effective for enhancing learning performance in various educational domains, such as mathematics (Kandemir & Gur, 2009), Engineering (Kashefi, Lsmail, & Yusof, 2012a), and nursing (Kane, 1983; Vanvactor, 2012).

* Corresponding author. Tel.: +886 915396558; fax: +886 6 3017001.
E-mail addresses: revonkuo@gmail.com (F.-R. Kuo), nschen@faculty.nsysu.edu.tw (N.-S. Chen), gjhwang@mail.ntust.edu.tw, gjhwang.academic@gmail.com (G.-J. Hwang).

0360-1315/$ – see front matter
http://dx.doi.org/10.1016/j.compedu.2013.11.005

Consequently, a creative thinking approach that integrates the Creative Problem Solving strategy into a web-based learning environment is proposed in this study and an experiment on the "Information Technology and Society" course of a university has been conducted. Moreover, to investigate the effectiveness of the proposed approach in depth, the students' cognitive styles were taken into account when analyzing their learning performance. The research questions of this study are listed as follows:

(1) Do the students who learn with the creative thinking approach have better web-based problem-solving performance than those who learn with traditional instruction?
(2) Do the students with different cognitive styles show different web-based problem-solving performance when learning with the creative thinking approach and with traditional instruction?

2. Literature review

2.1. Web-based problem solving ability

Web-based problem solving ability refers to one's ability to retrieve information on the web to respond to a series of questions related to a target issue (Hwang & Kuo, 2011). With the advent of Internet and Communication Technology (ICT), schools are not only playing the role of delivery of knowledge to students, but are also key to cultivating their web-based problem solving abilities in quick response to a pluralistic community. It is necessary to facilitate students' problem-solving abilities to adapt to a future changing society through training courses concerning information retrieval, recognition and reorganization processes (Goldstein & Levin, 1987; Mayer, 1992; Tsai, Tsai, & Hwang, 2011). Furthermore, Ifenthaler and Seel (2013) have indicated that supportive information is an essential assistance to learners for constructing cognitive structures to solve inductive reasoning and problem-solving tasks.

Kuo et al. (2012) have indicated that students' web-based problem solving performance is highly related to their competence of realizing problems, searching for information, selecting relevant information, and summarizing information. Previous studies have revealed several influential factors on students' web-based problem-solving abilities, such as intelligence quality, learning materials, learning strategies, learning facility, problem-solving instruction strategies, and the socioeconomic background of parents (Hwang & Kuo, 2011; Mustafa & Özgül, 2009; Oloruntegbe, Ikpe, & Kukuru, 2010; Zheng, 2007). Among these factors, learning strategies and problem-solving instruction strategies are considered as key (Harskamp & Suhre, 2007; Kuo et al., 2012; Lo, 2009; Tsai & Shen, 2009; Woo & Reeves, 2007). That is, embedding proper learning strategies in web-based problem-solving activities is helpful to students in improving their learning outcomes (Chiou, Hwang, & Tseng, 2009; Hwang, Chen, & Tsai, 2011; Jung & OuYang, 2004). Additionally, Ifenthaler (2013) argues that the development of effective web-based instruction requires suitable learning strategy and timely prompts for promoting such personalized and adaptive learning processes. Thus, how to apply ICT to facilitate students' web-based problem solving performance via providing proper learning strategies has become an important and challenging issue of learning design.

2.2. Creative Problem Solving strategies

Creative thinking is the process of surpassing learned principles and creating new methods for solving problems (Woolfolk, 1987). Researchers have indicated that these two processes can be integrated into a single complicated process, i.e. Creative Problem Solving (Guilford & Hoepfner, 1971; Kashefi, Ismail, & Yusof, 2012b; Wu, Hwang, Kuo, & Huang, 2013). Fig. 1 shows the Creative Problem Solving model proposed by Treffinger, Isaksen, and Dorval (1994). It consists of three components:

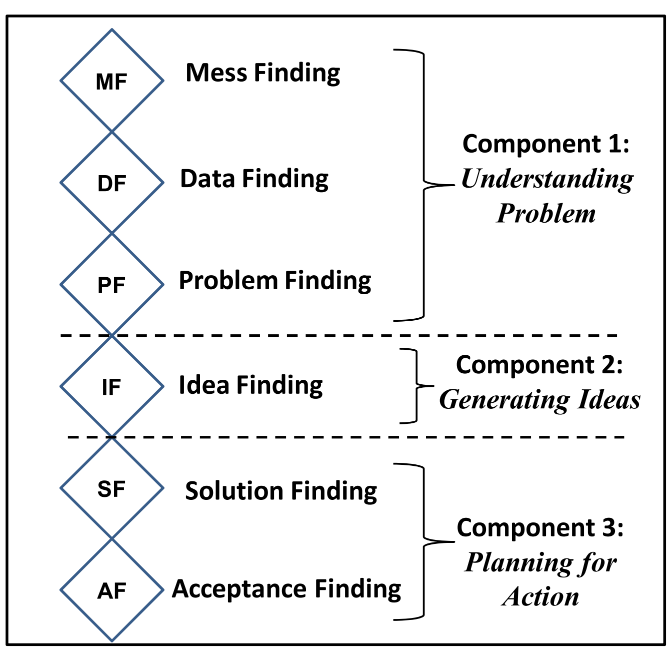

Fig. 1. The three components and six stages of Creative Problem Solving.

(1) Understanding the problem. This component consists of three stages: Mess Finding (MF), which refers to determining and selecting a goal, work or problem; Data Finding (DF), which refers to collecting data to explore feelings, impressions, observations, problems or work of stage-one facts, and deciding the focus; Problem Finding (PF), which refers to finding the problem and confirming it; narrating and refining the problem and thus making it clear.
(2) Generating ideas. This component is associated with the fourth stage: Idea Finding (IF), which refers to trying one's best to find many diversified and novel ideas, choices and alternative methods.
(3) Planning for action. This component consists of two stages: Solution Finding (SF), which refers to the development of a set of evaluation standards, using these standards to evaluate and clarify the merits, shortages and appropriateness of all ideas found in the former stage, as well as choosing the most useful solution; Acceptance Finding (AF), which refers to the use of the chosen solution, thinking about potential resistance to and assistance during implementation, as well as making this solution effectively develop and attain specified planning for action.

In the past decades, several studies have reported that Creative Problem Solving strategies have significant influences on students' learning performance (Cramond, Martin, & Shaw, 1988; Kashefi et al., 2012b; Khachakrit, Sangkom, & Sanit, 2011). Such a learning strategy is based on the cognitive schema theory, which educational psychologists argue that cognitive schema is one of important elements for creative thinking ability (Derry, 1996). Furthermore, diversifying learning experiences could enhance learners' cognitive flexibility and creative thinking (Ritter et al., 2012). However, those studies mainly applied Creative Problem Solving approach to traditional instruction. Using Creative Problem Solving approach to assist students to learn in technology-enhanced learning environments has rarely been seen.

2.3. Cognitive styles

Cognitive style refers to the way individuals think, perceive, and process information for solving problems via interacting with the environment (Birch & Hayward, 1994). There have been various cognitive styles proposed by researchers from different aspects (Allinson & Hayes, 1994; Messick, 1984; Riding & Cheema, 1991), such as holistic/analytic styles, verbal/imagery styles (Riding & Rayner, 1998), and intuitive/analytic styles (Ornstein, 1977). People with different cognitive styles usually reveal quite different behaviors when perceiving and processing information. For example, Olson (1985) has indicated that intuitive style people are likely to discover opportunities by observing cues or signals through unfamiliar and unorganized information processed in a synthetic and holistic way. On the other hand, analytic style people rely on sequential processing of information that enables them to evaluate and plan for the new solution; that is, they may present competency in judging and evaluating information, and selecting actions to implement skills that are needed in later stages of the creative process.

In the past decades, researchers have paid much attention to the relevance between students' cognitive styles and their learning performance in computer and web-based environments (Sadler-Smith, 1999a). For example, Effken and Doyle (2001) indicated that students' cognitive styles might affect their preferences for choosing computer simulation system interfaces, and thus influence their problem-solving efficiency and correctness. The study conducted by Liu, Chen, Hsiao and Lin (2006) showed that intuitive-type students tend to make judgments as per "feeling" and are prone to following existing thoughts and methods, whereas analytical-type students solve problems through mental inference and by focusing on details, and tend to address problems step by step.

Several studies have further demonstrated that students with different cognitive styles might prefer different learning methods (Allinson & Hayes, 1996; Hayes & Allinson, 1994; Huang, Lin, & Hwang, 2012; Luse, McElroy, Townsend, & DeMarie, 2013; Palo, Lin, & Larsson-Kraik, 2012; Sadler-Smith, 1999b; Thomas & McKay, 2010), implying that knowing the effects of learning strategies on the learning outcomes of students with different cognitive styles is helpful to researchers and teachers in developing more proper learning methods, learning materials and learning activities. For example, Duff (2004) has argued that it is important to develop students' learning competencies in accounting education by referring to different cognitive learning styles. Evans and Waring (2011) have indicated that cognitive learning styles could be an important determinant affecting student teacher assessment feedback preferences in teacher education. Therefore, in this study, the effects of the Creative Problem Solving strategy on analytical style and intuitive style students' performance are investigated as well.

3. Method

To evaluate the effectiveness of the proposed approach, an experiment was conducted on the "Information Technology and Society" course of a university in southern Taiwan. One of the objectives of the selected course was to help students realize the problems of the living environment and society as well as cultivating their problem solving abilities via using information technology.

3.1. Participants

The participants of the experiment were eighty freshmen (23 for male and 57 for female) from two classes of the Nursing department of a university, aging from 19 to 20. All of the students were taught by the same instructor and had experiences of using computers and accessing the web before the learning activity. One class was assigned to be the experimental group and the other was the control group. The experimental group with forty students experienced the web-based problem-solving activity with the creative thinking approach, while the control group with forty students participated in the identical learning activity with conventional instruction.

3.2. Learning environment with the Creative Problem Solving approach

A web-based learning system, Meta-Analyzer, was employed in the study. Meta-Analyzer allows teachers to design a series of stepwise questions to lead students to construct thematic knowledge based on the specific theme of the learning course (Hwang, Tsai, Tsai, & Tseng, 2008). Fig. 2 depicts the interface of Meta-Analyzer, which consists of a question and answer area for displaying questions in sequence and receiving the corresponding answers from the students, an information searching area which allows students to enter keywords to search

Fig. 2. A student searching for information to answer questions in the student interface of Meta-Analyzer.

for information on the web, an area to show the list of searched web pages, a pop-up window to display the current browsed page, and a web-page bookmark area which allows students to mark important searched pages.

Students need to perform web searching as well as analyzing, abstracting and integrating the information to complete their learning tasks. It is expected that, via seeking information to answer a series of questions related to the target problem, they are able to understand the problem progressively and further know how to solve the problem.

To embed the Creative Problem Solving approach in this web-based learning environment, a series of prompt questions were designed for each target issue to engage students in Fact Finding (FF), PF, IF, and SF tasks. In this approach, students need to complete the FF tasks via determining and selecting a goal, collecting data and deciding the focus. That is, an FF task contains MF and DF tasks in component 1 of Creative Problem Solving. For example, a Creative Problem Solving target issue "Phishing scams" might contain the following prompt questions:

FF: What is the difference between phishing scams and spam? What percentage of phishing events happened in 2011 compared to Internet security criminal events?
PF: What are the major behavioral patterns of victims found in the phishing scams?
IF: How can one avoid falling into the trap of phishing scams when receiving unknown emails?
SF: Regularly updating anti-virus software and spam filters is one way to avoid phishing scams. Can any other solutions be found?

Many research have proved that students' high-order thinking ability, such as problem-solving, and critical thinking ability, could be effectively improved by means of searching for web-based resource (Chang, Sung, & Lin, 2006; Chiou et al., 2009; Hwang, Wu, & Chen, 2012). Thus, to widen students' understanding of the given topics, learning approach embedded with Meta-Analyzer could be helpful to the students in knowledge construction.

3.3. Experimental design

Fig. 3 shows the experimental procedure. Before the learning activities, the students took a 75-min pre-test to identify their web-based problem solving ability and cognitive style. Moreover, an 80-min training course on the learning systems was given. Following that, a series of learning activities was conducted over a period of six weeks. Each week, a specific topic was given to the students. The students listened to a 30-min briefing on the topic, and then participated in an online theme-based discussion for 50 min. The six topics included "Phishing scams," "Internet security," "Information privacy," "Internet dating," "Credit card debt problems," and "Abandoned computer problems."

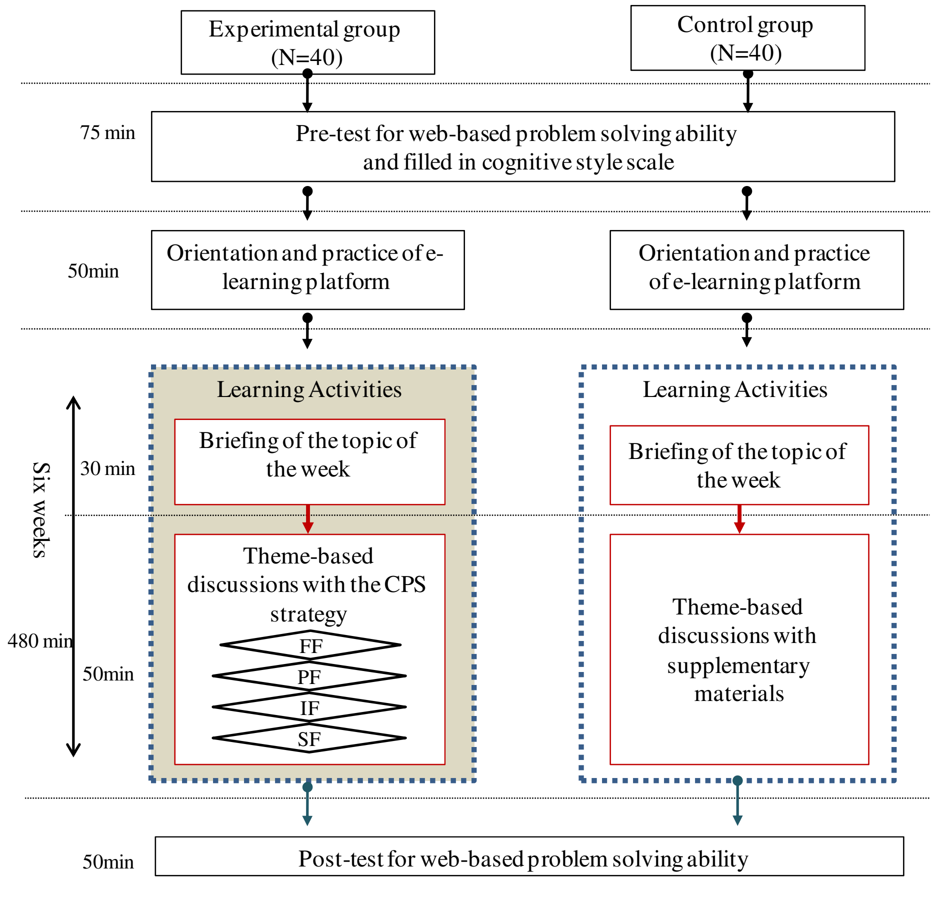

Fig. 3. Experimental procedure of the study.

During the learning activities in weeks 1–3, the experimental group students first took the Creative Problem Solving skill instruction, and then engaged in the theme-based discussions following the Creative Problem Solving strategy; that is, they were guided to complete the learning tasks based on the "fact finding," "problem finding," "ideas finding" and "solution finding" prompt questions before the discussions. In weeks 4–6, the students engaged in the theme-based discussions directly.

For the students in the control group, a conventional approach was adopted; that is, they were allowed to browse the supplementary materials, including the reference materials related to the learning tasks and the illustrative examples based on real cases, prepared by the teacher based on the same set of prompt questions when engaging in the theme-based discussions on the e-learning platform.

Finally, a 50-min web-based problem solving ability post-test was implemented to measure the students' learning effects.

3.4. Measuring tool

In the study, a set of web-based problem solving assessment criteria proposed by Khachakrit et al. (2011) and the scoring scheme based on the evaluation of creative thinking and problem solving abilities suggested by Isaksen and Parnes (1985) were adopted to evaluate the students' learning performance, including "fact finding," "problem finding," "idea finding," and "solution finding" (Khachakrit et al., 2011), as shown in Table 1. Fox example, if the discussed topic of the learning activity is "Phishing scams", and the question for the aspect of fact finding is given as "Please list what you have learned and consider what you need to know more in the article you read." The complete answer for the question is described as "The purpose of the phishing scams is to steal your personal identification, password of bank account, banking account no., credit card no., CVC and CVV etc. In addition, a phishing email, filter evasion, website forgery and phone phishing techniques are common phishing methods used by hackers." Thus, the more correct items a student can list, the higher score he/she will get. An example of teachers' scoring a student's answers is shown in Table 2.

An article, "Problems of Butterflies and Roads," developed by two senior lecturers and one professor with experience in creative thinking was employed in the pre-test and the post-test, as shown in Appendix 1. Based on the article, four progressive questions were designed and embedded in the learning system to engage students in FF, PF, IF, and SF tasks. In addition, students' divergent thinking and convergent thinking can be interplayed within these kinds of open questions and finally make proper decision for the given questions.

Through the four tasks, we could evaluate the fluency of thinking of student if they can come up with more viable solutions to the given problems. In addition, the items of both the pre-test and post-test were designed based on the living events but within a similar-item design.

For the reliability of the assessment, a total of 12 non-experimental students participated in the examination of content reliability and inter-rater reliability, and two professors and one lecturer were invited to conduct repeated discussions and revisions of the examination. Finally, Pearson correlation analysis showed that the four assessment dimensions reached 0.86, 0.88, 0.83 and 0.91 for inter-rater reliability, showing good reliability of the assessment scheme (Cohen, 1988).

Table 1
Scoring criteria for measuring students' web-based problem solving ability.

Dimension	Perfect score	Scoring criteria
Fact finding (FF)	15	1. Evaluate fluency of thinking; score as per quantity of "fact finding" (up to 10 points) 2. Consider flexibility of thinking; score as per whether the student can perceive the problem from different angles (each angle is given one point with a maximum score of 5 points)
Problem finding (PF)	15	1. Assess fluency of thinking; score as per quantity of "problem finding" (up to 6 points) 2. Evaluate preciseness of focus problem proposed. Score through 3 levels: precise (9 points); partially precise (6 points); not precise or unclear (3 points)
Ideas finding (IF)	15	1. Evaluate fluency of thinking; score as per quantity of ideas found (up to 8 points) 2. Summarize and generalize all testers' ideas and choose excellent answers with creativity and feasibility. These answers act as the scoring standard (up to 7 points).
Solution finding (SF)	15	1. Explain reasons and bases of choosing problem solving strategies, and then score the rationality of the explanation. (1). Rational (5 points), (2). Partially rational (3 points), (3). Not clear or irrational (1 point). 2. Evaluate preciseness and feasibility of problem solving scheme; three levels respectively. For preciseness, it includes (1). precise (5 points), (2). partially precise (3 points), (3). not clear or imprecise (1 point). 3. For feasibility, (1). feasible (5 points), (2). partially feasible (3 points), (3). not clear or unfeasible (1 point).

Furthermore, the Cognitive Style Index (CSI) developed by Allinson and Hayes (1996) was adopted as the cognitive style scale in this study for measuring whether the students had an intuitive or analytical style. CSI was a self-report questionnaire consisting of 21 items for measuring analytical-type thinking mode and 17 items for measuring intuitive-type thinking mode with a 3-point rating scheme: true (2 points); uncertain (1 point); false (0 point). Previous research investigated the effect of cognitive styles on students learning outcome by referring to Allinson and Hayes' CSI measurement (Franco, Meadows, & Armstrong, 2013; Hodgkinson & Sadler-Smith, 2003; Huang et al., 2012; Luse et al., 2013; Palo, et al., 2012; Sadler-Smith, 2011; Thomas & McKay, 2010). The Cronbach's α values of the analytical-style and intuitive-style measures were 0.84 and 0.92, respectively with high reliability (Cohen, 1998).

4. Results

4.1. Analysis of web-based problem solving ability

No significant difference was found from the *t*-test result on the pre-test scores of the two groups ($t = 0.75$, $p > .05$), meaning that the two groups' web-based problem solving abilities could be considered as equivalent before the learning activity.

To evaluate the effectiveness of the proposed approach, analysis of covariance (ANCOVA) was used to examine the post-test scores of the two groups by excluding the effect of their pre-test scores. As shown in Table 3, it was found that the experimental group students had significantly better learning performance than those in the control group ($F(1, 78) = 13.77$, $p < .001$) with effect size (η^2) of over 0.14 and

Table 2
An example of rater scoring for a student's answers to the "Phishing scams" open questions.

Dimension	Questions	Student answers	Rater scoring	Important points referred
Fact finding (FF)	Please list what you know and consider what more you need to know in the article you read.	From the article being read, I know the purpose of hackers by phishing scams is to steal Internet user's identification, password for bank account, banking account no., credit card no., etc.	9	The facts in the article tell readers of what target of hackers want: Identification, password for bank account, banking account no., Credit card no., CVC and CVV.
Problem finding (PF)	Are you aware of the important points in the article? Can you find the potential problems of the situation? List your questions.	I understand the purpose of hackers by means of phishing scams. What kinds of techniques can hackers use to do the phishing scams? Which technique is mostly used in phishing scam? How does the technique use to scam Internet users?	8	Questions should be included common techniques of phishing scams, the mostly used one, and what and how to prevent it.
Ideas finding (IF)	Could you propose some potential ideas for solving such a problem? List as many as possible, but do not judge which is better or worse.	I am thinking the mostly used in phishing scam could be phishing email. The potential ideas for the phishing email are to eliminate the email, and to verify the content of email source.	8	The point of the question should mainly mention the verification of the phishing scam and possible traps.
Solution finding (SF)	Choose the most likely solution, and your reasons. Be sure to list concrete practices and steps, as well as how to put them into action to solve the problem.	Many people contact their friends or colleagues by email frequently. Thus, emails appear to come from a legal source such as a trusted financial institution, and includes an urgent request for personal information usually invoking some critical need to update an account immediately. Clicking on a link provided in the email leads to an official-looking website. Personal information provided to this site, however, goes directly to the scam guys. Thus, we need to be aware of such a phishing scam when receiving the phishing email. To further ensure the legitimization of the source. In addition, it is necessary to update anti-virus software regularly.	12	The guideline of the question should contain possible solutions and reason to above-mentioned problems. In addition, to list concrete action plans are needed.

Table 3
ANCOVA of web-based problem solving ability of the two groups.

	Groups	*N*	Mean	SD	df	Adjusted mean	Se	*F*	η^2
Web-based problem solving ability	Ctl. group	40	22.36	8.57	77	22.20	1.11	13.77***	0.15
	Exp. group	40	27.76	8.07		28.03	1.12		

***$p<.001$.

showed a large effect size (Cohen, 1988)., implying that the Creative Problem Solving approach could improve the students' web-based problem solving ability.

Table 4 further shows the *t*-test results of the students' post-test scores of individual web-based problem-solving dimensions. It was found that the two groups of students showed significantly different performances in the problem finding ($t = -2.13$, $p < .05$) and idea finding ($t = -6.05$, $p < .001$) dimensions with effect size (η^2) of over 0.14 and showed a large effect size (Cohen, 1988). That is, the Creative Problem Solving approach was helpful to the students in improving their problem-finding and idea-finding abilities.

4.2. Analysis of web-based problem solving abilities of students with different cognitive styles

To further compare the learning performances of the students with different cognitive styles, the students were grouped into two categories, intuitive and analytical cognitive style, according to their scores. The students with the bottom 27% of CSI scores were categorized into the intuitive type, whereas those with the top 27% of CSI scores were the analytical type (Spanier & Tate, 1988). Table 5 shows the number of intuitive-type and analytical-type students in the two groups.

The *t*-test results of the pre-test scores of the two groups of students with identical cognitive styles. No significant difference was found between the pre-test scores of the students with identical cognitive styles in the two groups with $t = -0.22$ ($p > .05$) for analytical type and $t = -0.15$ ($p > .05$) for intuitive type. That is, both the intuitive-type and analytical-type students in the two groups had equivalent web-based problem-solving ability before the learning activity.

Table 6 presents the *t*-test results of the post-test scores of students with identical cognitive styles in the two groups. It was found that the intuitive-type students in the experimental group had significantly higher post-test scores than those in the control group ($t = -2.17$, $p < .05$) with effect size (η^2) of over 0.14 and showed a large effect size (Cohen, 1988), implying that the Creative Problem Solving approach is generally more helpful to intuitive-type than to analytical-type students.

4.2.1. Analytical-type students' performance in individual problem-solving dimensions

To further understand the influences of the Creative Problem Solving strategy on the analytical-type students' web-based problem-solving performances, the students' pre-test and post-test scores of individual web-based problem-solving dimensions were analyzed. Table 7 shows the MANCOVA results excluding the influences of the pre-test. It was found that the analytical-type students of the two groups reached a significant level in the post-test of idea finding ($F(1, 21) = 11.65$, $p < .01$) with effect size (η^2) of over 0.14 and showed a large effect size (Cohen, 1988). That is, the Creative Problem Solving approach significantly benefited the analytical-type students in improving their idea finding performance.

4.2.2. Intuitive-type students' performance in individual problem-solving dimensions

Similarly, the intuitive-type students' performances in terms of the four web-based problem-solving dimensions were analyzed as well. Table 8 presents the ANCOVA results excluding the influences of the pre-test. It was found that the intuitive-type students in the experimental group had significantly better performance than those in the control group in terms of "fact finding" ($F(1,20) = 2.55$, $p < .05$), "problem finding" ($F(1,20) = 7.44$, $p < .05$), and "idea finding" ($F(1,20) = 7.16$, $p < .05$) with effect size (η^2) of over 0.14 and showed a large

Table 4
Independent Sample *t*-test of the post-test of the problem solving process.

Index of problem solving process	Groups	*N*	df	Mean	SD	*t*	η^2
Fact Finding	Ctl. group	40	78	6.80	1.89	−0.65	0.07
	Exp. group	40		7.06	1.73		
Problem Finding	Ctl. group	40	78	5.99	3.09	−2.13*	0.24
	Exp. group	40		7.39	2.77		
Idea Finding	Ctl. group	40	65	3.03	1.65	−6.05***	0.61
	Exp. group	40		5.99	2.62		
Solution Finding	Ctl. group	40	78	6.55	4.15	−0.93	0.10
	Exp. group	40		7.33	3.25		

*$p<.05$, ***$p<.001$.

Table 5
Classification of cognitive styles for the two groups.

Cognitive style	Group	Score	Number of students
Analytical-type	Ctl. group	≥55	13
	Exp. group	≥55	11
Intuitive-type	Ctl. group	≤46	11
	Exp. group	≤45	11

Table 6
Independent Sample *t*-test of the post-test of web-based problem solving ability within different cognitive styles.

Type of cognitive style	Groups	N	df	Mean	SD	t	η^2
Analytical type	Ctl. group	13	22	21.58	8.02	−0.99	0.20
	Exp. group	11		24.55	6.46		
Intuitive type	Ctl. group	11	20	21.45	8.00	−2.17*	0.44
	Exp. group	11		29.50	9.34		

*p<.05.

Table 7
MANCOVA of indexes of problem solving process for analytical-type students.

Index of problem solving process	Control group (N = 13) experimental group (N = 11)					F	η^2
	df	Means	SD	Means	SD		
Fact finding	1	6.58	1.44	6.41	1.96	0.36	0.02
Problem finding	1	5.92	3.33	6.18	2.27	0.55	0.03
Idea finding	1	3.23	1.36	5.77	2.44	11.65**	0.39
Solution finding	1	5.85	3.91	6.18	2.89	0.37	0.02

**p<.01.

effect size (Cohen, 1988). That is, the Creative Problem Solving approach significantly benefited the intuitive-type students in improving their “fact finding,” “problem finding,” and “idea finding” abilities.

5. Discussion and conclusions

In this study, a Creative Problem Solving approach for improving students’ web-based problem-solving performance is proposed. Moreover, an experiment was conducted to evaluate the effectiveness of the proposed approach in terms of different cognitive-type students’ learning performance. The results indicate that the Creative Problem Solving approach was generally more helpful to the intuitive-type than to the analytical-type students. In addition, further analysis results showed that the proposed approach could significantly improve analytical-type students’ idea finding performance. In the meantime, it improved the intuitive-type students’ “fact finding,” “problem finding,” and “idea finding” performance. Literature has pointed out that intuitive-type people often make prompt judgments based on their feelings, and favor exploratory environments when solving problems (Allinson & Hayes, 1996; Hodgkinson & Clarke, 2007), which could be the reason why the Creative Problem Solving approach influenced the intuitive-type more than the analytical-type students.

Based on the findings, it is suggested that, for analytical-type students, learning activities can be designed with independent learning and mental inference approaches, as indicated by several researchers (Allinson & Hayes, 1996; Hayes & Allinson, 1994; Sadler-Smith, 1999b). On the other hand, it would be better for intuitive-type students to learn with guided exploratory strategies in collective learning contexts (Evans & Waring, 2011; Hayes & Allinson, 1998; Masiello, Ramberg, & Lonka, 2005; Miner, 1997; Olson, 1985; Sadler-Smith, 2011; Shioh & Shnhav-Sheffer, 2004).

The findings are also related to the viewpoint of Jenkins (1998) and Rimiene (2002) that critical thinking ability, creative thinking ability and inferential thinking ability have significant correlations. When learners are solving a problem using web resources, their web searching performances are significantly related to their three kinds of thinking abilities; moreover, such an ability of searching for and using web resources is highly related to their problem solving performance (Chiou et al., 2009; Harris & Blank, 1983; Hwang, Kuo, Chen, & Ho, 2013; Kuo et al., 2012; Raes, Schellens, Wever, & Vanderthoven, 2012; She et al., 2012; Swartz & Parks, 1994). Therefore, this study has provided a potential strategy for cultivating students’ thinking skills (e.g., searching ability, creative thinking ability, critical thinking ability and inferential thinking ability) as well as their problem-solving ability. That is, the developed web-based creative thinking learning environment could effectively help students be more likely to come up with potential solution with divergent and convergent thinking processes than traditional CPS environment. Furthermore, within a web-based creative thinking environment, educators could have chances to investigate students’ changes during their problem solving process between the pre-test and post-test. In the meantime, it also shows the effectiveness of the approach in helping different cognitive style students in individual web-based problem-solving dimensions.

A few limitation of the study must be pointed out. Our sample was limited to one group, university nursing students. Replicating our findings to other student groups with different backgrounds is essential before generalizations can be made with confidence. In addition, although the focus of the study has been on cognitive styles, it should be noted that other human factors may affect learners’ interaction with the Internet, including affective factors, gender differences and age differences. Consequently, an important direction for future work is the investigation of these factors and the identification of the major design features which interact with each other. Moreover, the present

Table 8
MANCOVA of indexes of problem solving processes for intuitive-type students.

Index of problem solving process	Control group (N = 11) experimental group (N = 11)					F	η^2
	df	Means	SD	Means	SD		
Fact finding	1	6.14	2.25	7.73	1.89	2.55*	0.14
Problem finding	1	5.50	2.36	8.14	2.12	7.44*	0.32
Idea finding	1	2.73	1.47	5.82	2.89	7.16*	0.31
Solution finding	1	7.09	4.28	7. 82	3.31	0.26	0.01

*p<.05.

study adopted a quantitative method to conduct students' learning performance, in which showed insufficient internal reliabilities. Thus, a direct qualitative method for objective results is desirable, and may improve reliabilities and validate the creative thinking process.

Acknowledgments

The authors would like to thank Miss Chun-Yen Wu and Miss I–Ru Lin for their assistance in conducting the experiment. This study is supported in part by the National Science Council of the Republic of China under contract numbers NSC101-2511-S-011-005-MY3 and NSC100-2911-I-110-503.

Appendix 1

The "Problem of Butterflies and Roads" in Taiwan

Butterflies and Roads
Every spring, a large number of butterflies need to fly toward northern Taiwan from Mao-Lin village in southern Taiwan for propagation after the winter. On the way to northern Taiwan, these butterflies pass through the middle areas of Taiwan, including Yu-Lin city and county, around early April. After aggregation of butterflies from different areas, the butterflies can be viewed as a spectacular "air trail" which keeps flying toward the north of Taiwan. However, due to the long distance to their destination, the butterflies need to pass the highway located in the middle village of Changhua county. It is estimated that nearly 300 butterflies per minute fly over the highway, risking being hit by cars. Consequently, the villagers have a profound emotion regarding the butterflies and look forward to seeing them every year in this season. However, they also need the current highway which provides convenient transportation. This situation poses a problem that they don't know how to solve. Thus, what suggestions would you offer to the government, and how would you help them to address such a problem if you were one of the villagers?

Carefully think about and try to answer the following questions based on the article:

1. List what you know and consider what more you need to know. For example, what needs more consideration when constructing the highway? Does the ecology around the road need to be conserved or changed? (100–300 words required)
2. Are you aware of the important points in the article? Can you find the potential problems of the situation? List your questions. (100–300 words required)
3. Could you propose some potential ideas for solving such a problem? List as many as possible, but do not judge which is better or worse.
4. Choose the most likely solution, and your reasons. Be sure to list concrete practices and steps, as well as how to put them into action to solve the problem (at least 300 words required).

References

Abell, S. K. (1990). The problem-solving muse. *Science and Children, 28*(2), 27–29.
Ackerman, E., & Karen, H. (2005). *Searching and researching on the Internet and the World Wide Web* (4rd ed.). Wilsonville, OR: Franklin Beedle.
Allinson, C. W., & Hayes, J. (1994). Matching the cognitive styles of management students and teachers: a preliminary study. *Perceptual and Motor Skills, 79*(3), 1256–1258.
Allinson, C. W., & Hayes, J. (1996). The cognitive style index: a measure of intuition-analysis for organizational research. *Journal of Management Studies, 33*(1), 119–135.
Bilal, D. (2002). Children's use of the Yahooligans! Web search engine. III. Cognitive and physical behaviors on fully self-generated search tasks. *Journal of the American Society for Information Science and Technology, 53*(13), 1170–1183.
Birch, A., & Hayward, S. (1994). *Individual difference*. The Macmillan Press Ltd.
Bruno, J. E. (1987). Admissible probability measures in instructional management. *Journal of Computer-based Instruction, 14*(1), 23–30.
Chang, K. E., Sung, Y. T., & Lin, S. F. (2006). Computer-assisted learning for mathematical problem solving. *Computers & Education, 46*(2), 140–151.
Chiou, C. K., Hwang, G. J., & Tseng, J. C. R. (2009). An auto-scoring mechanism for evaluating problem-solving ability in a web-based learning environment. *Computers & Education, 53*(2), 261–272.
Clerehan, R., Kett, G., Gedge, R., & Tuovinen, J. E. (2003). Encouraging IT students to get serious about assignment writing: evaluation of a Web-based initiative. *The Internet and Higher Education, 6*(4), 327–346.
Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). New Jersey: Lawrence Erlbaum.
Cramond, B., Martin, C. E., & Shaw, E. L. (1988). An investigation of the application of training in creative problem solving to content area problem. In *Paper presented at the annual meeting of the American educational research association, New Orleans, LA.., 1988, April*.
Derry, S. (1996). Cognitive schema theory in the constructivist debate. *Educational Psychologist, 31*(3/4), 163–174.
Dickey, M. D. (2007). Barriers and enablers in integrating cognitive apprenticeship methods in a Web-based educational technology course for K–12 (primary and secondary) teacher education. *Research in Learning Technology, 15*(2), 119–130.
Duff, A. (2004). The role of cognitive learning styles in accounting education: developing learning competencies. *Journal of Accounting Education, 22*(1), 29–52.
Effken, J. A., & Doyle, M. (2001). Interface design and cognitive style in learning an instructional computer simulation. *Computers in Nursing, 19*(4), 164–171.
Eisenberg, M. B., & Berkowitz, R. E. (2000). *Teaching information & technology skills: The big6 in secondary schools*. Worthington, OH: Linworth Publishing.
Evans, C., & Waring, M. (2011). Student teacher assessment feedback preferences: the influence of cognitive styles and gender. *Learning and Individual Differences, 21*, 271–280.
Franco, L. A., Meadows, M., & Armstrong, S. (2013). Exploring individual differences in scenario planning workshops: a cognitive style framework. *Technological Forecasting and Social Change, 80*(4), 723–734.
Goldstein, F. C., & Levin, H. S. (1987). Disorders of reasoning and problem-solving ability. In M. Meier, A. Benton, & L. Diller (Eds.), *Neuropsychological rehabilitation*. London: Taylor & Francis Group.
Guilford, J. P., & Hoepfner, R. (1971). *The analysis of intelligence*. New York: McGraw-Hill.
Harris, D. G., & Blank, S. S. (1983). A comparative study: two approaches to enhance creative problem-solving in grade five students. *B. C. Journal of Special Education, 7*(2), *129–152*.
Harskamp, E., & Suhre, C. (2007). Schoenfeld's problem solving theory in a student controlled learning environment. *Computers & Education*, 49(3), *822–839*.
Hayes, J., & Allinson, C. W. (1994). Cognitive style and its relevance for management practice. *British Journal of Management, 5*(1), 53–71.
Hayes, J., & Allinson, C. W. (1998). Cognitive style and the theory and practice of individual and collective learning in organizations. *Human Relations, 51*(7), 847–871.
Hodgkinson, G. P., & Clarke, I. (2007). Exploring the cognitive significance of organizational strategizing: a dual-process framework and research agenda. *Human Relations, 60*(1), 243–255.
Hodgkinson, G. P., & Sadler-Smith, E. (2003). Complex or unitary? A critique and empirical re-assessment of the Allinson–Hayes Cognitive Style Index. *Journal of Occupational and Organizational Psychology, 76*(2), 243–268.
Huang, E. Y., Lin, S. W., & Hwang, T. K. (2012). What type of learning style leads to online participation in the mixed-mode e-learning environment? A study of software usage instruction. *Computers & Education, 58*(1), 338–349.

Hwang, G. J., Chen, C. Y., Tsai, P. S., & Tsai, C. C. (2011). An expert system for improving web-based problem-solving ability of students. *Expert Systems with Applications, 38*(7), 8664–8672.

Hwang, G. J., & Kuo, F. R. (2011). An information-summarizing instruction strategy for improving web-based problem solving abilities of students. *Australian Journal of Educational Technology, 27*(2), 290–306.

Hwang, G. J., Kuo, F. R., Chen, N. S., & Ho, H. J. (2013). Effects of an integrated concept mapping and web-based problem-solving approach on students' learning achievements, perceptions and cognitive loads. *Computers & Education*. http://dx.doi.org/10.1016/j.compedu.2013.09.013.

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.

Hwang, G. J., Wu, P. H., & Chen, C. C. (2012). An online game approach for improving students' learning performance in web-based problem-solving activities. *Computers & Education, 59*(4), 1246–1256.

Ifenthaler, D. (2013). Cognitive, metacognitive and motivational perspectives on preflection in self-regulated online learning. *Computers in Human Behavior*. http://dx.doi.org/10.1016/j.chb. 2013.07.051.

Ifenthaler, D., & Seel, N. M. (2013). A longitudinal perspective on inductive reasoning tasks. Illuminating the probability of change. *Learning and Instruction, 21*(4), 536–549.

Isaksen, S. G., & Parnes, S. J. (1985). Curriculum planning for creative thinking and problem solving. *The Journal of Creative Behavior, 19*(1), 1–29.

Jenkins, E. K. (1998). The significant role of critical thinking in predicting auditing students' performance. *Journal of Education for Business, 73*(5), 274–279.

Jung, C. Y., & OuYang, Y. (2004, April). The effects of cooperation learning in web-based environment on elementary students' problem solving ability in social study. In *Paper presented at the conference of digital learning, Pingtung, Taiwan*.

Kandemir, M. A., & Gur, H. (2009). The use of creative problem solving scenarios in mathematics education: views of some prospective teachers. *Social and Behavioral Science, 1*(1), 1628–1635.

Kane, S. (1983). Creative problem solving for health care professionals. *AORN Journal, 37*(5), 876.

Kashefi, H., Ismail, Z., & Yusof, Y. M. (2012b). Supporting engineering students' thinking and creative problem solving through blended learning. *Social and Behavioral Sciences, 56*, 117–125.

Kashefi, H., Lsmail, Z., & Yusof, Y. (2012a). Engineering mathematics obstacles and improvement: a comparative study of students and lecturers perspectives through creative problem solving. *Social and Behavioral Science, 56*, 556–564.

Kear, K. L., & Heap, N. W. (2007). Sorting the wheat from the chaff: investigating overload in educational discussion systems. *Journal of Computer Assisted Learning, 23*(3), 235–247.

Khachakrit, L., Sangkom, P., & Sanit, K. (2011). Developing a web-based instruction blended learning model using the creative problem solving process for developing creative thinking and problem solving thinking of undergraduate students. *European Journal of Social Science, 24*(2), 246–251.

Kuo, F. R., Hwang, G. J., & Lee, C. C. (2012). A hybrid approach to prompting students' web-based solving competence and learning attitude. *Computers & Education, 58*(1), 351–364.

Ladbrook, J., & Probert, E. (2011). Information skills and critical literacy: where are our digikids at with online searching and are their teachers helping? *Australasian Journal of Educational Technology, 27*(1), 105–121.

Lee, C. B. (2010). The interactions between problem solving and conceptual change: system dynamic modeling as a platform for learning. *Computers & Education, 55*(3), 1145–1158.

Liu, C. C., Cheng, Y. B., & Huang, C. W. (2011). The effect of simulation games on the learning of computational problem solving. *Computers & Education, 57*(3), 1907–1918.

Liu, T. C., Chen, Y. C., Hsiao, C. L., & Lin, Y. C. (2006, June). Exploring the effects of simulation based learning on college students' statistical understanding, misconception, and attitude. In *Paper presented at the meeting of the 10th annual global conference on computers in education, Beijing, China*.

Lo, H. (2009). Utilizing computer-mediated communication tools for problem-based learning. *Journal of Educational Technology & Society, 12*(1), 205–213.

Luse, A., McElroy, J. C., Townsend, A. M., & DeMarie, S. (2013). Personality and cognitive style as predictors of preference for working in virtual teams. *Computers in Human Behavior, 29*(4), 1825–1832.

Masiello, I., Ramberg, R., & Lonka, K. (2005). Attitudes to the application of a Web-based learning system in a microbiology course. *Computers & Education, 45*(2), 171–185.

Mayer, R. E. (1992). *Thinking, problem solving, cognition* (2nd ed.). New York: W. H. Freeman and Company.

Messick, S. (1984). The nature of cognitive styles: problems and promise in educational practice. *Educational Psychologist, 19*, 59–74.

Miner, J. B. (1997). *A psychological typology of successful entrepreneurs*. London: Quorum Books.

Mustafa, S., & Özgül, Y. T. (2009). Elementary students' metacognition and epistemological beliefs considering science achievement, gender and socioeconomic status. *Elementary Education Online, 8*(3), 676–693.

Oloruntegbe, K. O., Ikpe, A., & Kukuru, J. D. (2010). Factors in students' ability to connect school science with community and real-world life. *Educational Research and Reviews, 5*(7), 372–379.

Olson, P. D. (1985). Entrepreneurship: process and abilities. *American Journal of Small Business, 10*(1), 25–31.

Ornstein, R. E. (1977). *The psychology of consciousness*. New York: *Harcourt Brace*.

Palo, M., Lin, J., & Larsson-Kraik, P. O. (2012). Maintenance performance improvement for rolling stock wheels*. 33*, 727–732.

Raes, A., Schellens, T., Wever, B. D., & Vanderthoven, E. (2012). Scaffolding information problem solving in web-based collaborative inquiry learning. *Computers & Education, 59*(1), 82–94.

Riding, R. J., & Cheema, I. (1991). Cognitive styles – an overview and integration. *Educational Psychology, 11*, 193–215.

Riding, R., & Rayner, S. (1998). *Cognitive style and learning strategies*. London: David Fulton.

Rimiene, V. (2002). Assessing and developing students' critical thinking. *Psychology Learning and Teaching, 2*(1), 17–22.

Ritter, S. M., Damian, R. I., Simonton, D. K., van Baaren, R. B., Strick, M., Derk, J., et al. (2012). Diversifying experiences enhance cognitive flexibility. *Journal of Experimental Social Psychology, 48*, 961–964.

Sadler-Smith, E. (1999a). Intuition-analysis cognitive style and learning preferences of business and management students: a UK exploratory study. *Journal of Managerial Psychology, 14*(1), 26–38.

Sadler-Smith, E. (1999b). Intuition-analysis style and approaches to studying. *Educational Studies, 25*(2), 159–173.

Sadler-Smith, E. (2011). The intuitive style: relationships with local/global and verbal/visual styles, gender, and superstitious reasoning. *Learning and Individual Differences, 21*(3), 263–270.

Scherer, R., & Tiemann, R. (2012). Factors of problem-solving competency in a virtual chemistry environment: the role of metacognitive knowledge about strategies. *Computers & Education, 59*(4), 1199–1214.

She, H. C., Cheng, M. T., Li, T. W., Wang, C. Y., Chiu, H. T., Lee, P. Z., et al. (2012). Web-based undergraduate chemistry problem-solving: the interplay of task performance, domain knowledge and web-searching strategies. *Computers & Education, 59*(2), 750–761.

Shiloh, S., & Shenhav-Sheffer, M. (2004). Structure of difficulties in mate-selection decisions and its relationship to rational and intuitive cognitive styles. *Personality and Individual Differences, 37*(2), 259–273.

Siragusa, L., Dixon, K. C., & Dixon, R. (2007). Designing quality e-learning environments in higher education. In *ICT: Providing choices for learners and learning. Proceedings ascilite Singapore 2007.* In *http://www.ascilite.org.au/conferences/singapore07/procs/siragusa.pdf*.

Spanier, A., & Tate, F. S. (1988). Embedded figures performance and telecourse achievement. *The Journal of General Psychology, 115*(4), 425–431.

Swartz, R., & Parks, S. (1994). *Infusing the teaching of critical and creative thinking into content instruction: A lesson design handbook for the elementary grades*. Pacific Grove, CA: Critical Thinking Books and Software.

Thomas, P. R., & McKay, J. B. (2010). Cognitive styles and instructional design in university learning. *Learning and Individual Differences, 20*(3), 197–202.

Thompson, S. D., Martin, L., Richards, L., & Branson, D. (2003). Assessing critical thinking and problem solving using a Web-based curriculum for students. *The Internet and Higher Education, 6*(2), 185–191.

Treffinger, D. J., & Isaksen, S. G. (1992). *Creative problem solving: An introduction*. Sarasota, FL: Center for Creative Learning.

Treffinger, D. J., Isaksen, S. G., & Dorval, K. B. (1994). Creative problem solving: an overview. In M. A. Runco (Ed.), *Problem finding, problem solving, and creativity*. New Jersey: Ablex Publishing Corporation.

Tsai, C. W., & Shen, P. D. (2009). Applying web-enabled self-regulated learning and problem-based learning with initiation to involve low-achieving students in learning. *Computers in Human Behavior, 25*(6), 1189–1194.

Tsai, P. S., & Tsai, C. C. (2013). College students' experience of online argumentation: conceptions, approaches and the conditions of using question prompts. *The Internet and Higher Education, 17*, 38–47.

Tsai, P. S., Tsai, C. C., & Hwang, G. J. (2011). The correlates of Taiwan teachers' epistemological beliefs concerning Internet environments, online search strategies, and search outcomes. *The Internet and Higher Education, 14*(1), 54–63.

Tseng, C. R., Hwang, G. J., Tsai, P. S., & Tsai, C. C. (2009). Meta-analyzer: a web-based learning environment for analyzing student information searching behaviors. *International Journal of Innovative Computing, Information and Control, 5*(3), 567–579.
Vanvactor, J. D. (2012). Collaborative leadership model in the management of health care. *Journal of Business Research, 65*(4), 555–561.
Woo, Y., & Reeves, T. C. (2007). Meaningful interaction in web-based learning: a social constructivist interpretation. *The Internet and Higher Education, 10*(1), 15–25.
Woolfolk, A. E. (1987). *Educational psychology* (3rd ed.). New Jersey: Simon and Schuster.
Wu, C. H., Hwang, G. J., Kuo, F. R., & Huang, I. (2013). A mindtool-based collaborative learning approach to enhancing students' innovative performance in management courses. *Australasian Journal of Educational Technology, 29*(1), 128–142.
Zheng, Z. (2007). Gender differences in mathematical problem solving patterns: a review of literature. *International Education Journal, 8*(2), 187–203.