



Effect of metacognitive strategies and verbal-imagery cognitive style on biology-based video search and learning performance

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ABSTRACT

Videos have diverse content that can assist students in learning. However, because videos are linear media, video users may take a longer time than readers of text to evaluate the context. Therefore, the process of video search may vary from one user to another depending on the users' individual characteristics, and the effectiveness of video learning may also vary across individuals. This study evaluated 100 Taiwanese fifth graders searching for videos related to “understanding animals” on YouTube and examined the effects of the students' metacognitive strategies (planning, monitoring, and evaluating) and verbal-imagery cognitive style on their video searches. The observable indicators were quantitative (search behaviors, search performance, and learning performance) and qualitative (search process observations and interviews). The study concludes that metacognitive strategy is the primary influencer of video search. Students with better metacognitive skills used fewer keywords, browsed fewer videos, and spent less time evaluating videos, but they achieved higher learning performance. They reviewed the video metadata information on the user interface and did not attempt to watch videos on the video recommendation lists, particularly videos that were irrelevant to the task requirements. During the course of the searches, keyword usage had a significant influence on the students' search performance and learning performance. The fewer keywords the students used, the better search and learning performance they were able to achieve. Our results are different from those of previous studies on text, image, and map searches. Accordingly, users must adopt different search strategies when using various types of search engines.

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1. Introduction

Web information retrieval has become one of the main sources for computer-assisted learning and digital materials. There are an increasing number of different formats for web information, including text, images, music and video (Tjondronegoro,

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Spink, & Jansen, 2009). In earlier years, students could only access texts due to constraints of network bandwidth and technology. Recently, the number of different multimedia formats has greatly increased. With the proliferation of video/music sharing websites (such as YouTube) and the spirit of sharing and reproducing of Web 2.0, the number of short films shared on these databases has shot up to the millions. These websites provide easily accessible channels with user-friendly platforms to inundate students with video information. In addition to providing entertaining content, these videos serve as educational materials and teaching tools (Nikopoulou-Smyrni & Nikopoulos, 2010; Zhang, Zhou, Briggs, & Nunamaker, 2006). Asensio and Young (2002), Champoux (1999), Clark and Paivio (1991), Karppinen (2005), Mayer, Steinhoff, Bower, and Mars (1995), Smeaton and Browne (2006), and Torres-Ramírez, García-Domínguez, Aguilera, and de la Casa (2014) noted that scientific concepts are sometimes too abstract or complicated to be comprehensible. However, the right visual videos (e.g., that show a real animal or a live chemistry process) can help students grasp a concept completely and accurately. Videos can serve as tools that provide multiple presentation and browsing methods (e.g., consecutive scenes, voice for explanations and subtitles for text descriptions). Videos stimulate multiple senses and effectively crystalize abstract concepts using a combination of visuals, text, voice and music. An effective knowledge constructor can actively select and connect pieces of visual and verbal knowledge (Mayer, 1997). Comprehension depends on the successful storage of these connections along the two forms of mental representation (verbal and visual) of these propositions or ideas in long-term memory (Plass, Chun, Mayer, & Leutner, 2003). Therefore, videos can help students comprehend and memorize information, improve their cognitive processes and enhance their learning performance.

Training students how to retrieve information from the Internet for learning is important to teaching them how to utilize Internet technology and information (Clifton & Mann, 2011; Kuo, Hwang, & Lee, 2012; Laxman, 2010; Sun, Ye, & Hsieh, 2014). Because different types of search engines require different search and cognitive processes, it seems reasonable to consider search engines within three types of formats: text, image, and video searches. Text searches require the comprehension of connotations of a given topic and the use of related ideas to formulate keywords. Because it is easy for students to focus on and search for information via definitive keywords, it only takes them a few searches to retrieve the correct documents or answers. In contrast, picture or image searches require theme formulation and the ability to envision the potential results. Given that many current image retrieval systems are keyword-based, users must translate their visions into literal descriptions, and the pictures stored in databases must have descriptive words or metadata that match the selected keywords (Fukumoto, 2006; Hou & Ramani, 2004). Search systems transmit some pictures for users to compare, assess, and decide whether they need to continue a search. Accordingly, image searches can be analyzed as mixed acts of image-text cross-referencing, observation, judgment, decision-making, and correction. Note that the existence of semantic gaps and the lack of precise characteristics make image searches more abstract and complex than text searches (Choi, 2010; Cunningham & Masoodian, 2006).

In terms of video searches, because videos encompass various formats, evaluating whether video content fulfills users' expectations takes longer than searching for texts and images. Furthermore, in digital environments, the supplementary tools provided by search engines may also influence search behaviors, strategies and performance. Video search engines provide a less frequently observed tool than other types of search engines: the video recommendation system (see Fig. 1). This tool "recommends" other videos that are considered pertinent to the watched video (irrelevant to keywords) for the users' reference by analyzing the search process of individual users and the knowledge structure within the system (Davidson et al., 2010; Zhou, Khemmarat, & Gao, 2010). This function is common on video and music sharing websites. The design aims to provide convenience for users rather than helping them learn better. Thus, it may be an additional significant factor in the video search process. Retrieved videos may come from the suggestion of users based on the relevance of the pictures and the texts, and they may also be contributed from recommendations made by the system. In terms of learning, we must be careful to distinguish whether search results are selected by the students or suggested by the system. Will the recommendations of the system be a distraction if the students use improper keywords or view irrelevant videos? A "video recommendation system" can provide both benefits and risks to users. It allows users to quickly browse videos related to the topics that they care about, but it can also lead users to watch a series of videos that are irrelevant to their original search target, which may cause the users to believe that such search results are useful. Thus, when evaluating learning effectiveness in the course of video search, we must take this function into consideration. In sum, the similarities and differences between the three types of search engines are presented in Table 1. Different types of search engines may lead diverse factors to influence search behaviors, strategies and performance due to different search and cognitive processes. Video search is no exception. However, to date, few researchers have made the effort to explore the video search process (Albertson, 2010a; Burke, Snyder, & Rager, 2009; Clifton & Mann, 2011; Lee & Lehto, 2013; Snelson & Elison-Bowers, 2009; Torres-Ramírez et al., 2014; Uzunboylu, Bicen, & Cavus, 2011). This study aims to analyze and define the individual characteristics that affect students' abilities to effectively use video search engines.

Previous studies have proposed that information-seeking behaviors are complex cognitive processes (Laxman, 2010; Lin & Tsai, 2007; Walraven, Brand-gruwel, & Boshuizen, 2008). Before embarking upon any meaningful search activities, a searcher must understand the questions that they have or the nature of the search tasks by means of the searcher's existing knowledge. The searcher must decide the approximate location of the target in the cyber world (for example, the user must decide between searching general webpages, news articles, blogs, videos, pictures, or maps) and choose a search engine. Then, the searcher can formulate keywords for the search. In the course of the search, the searcher must input a keyword and then review each video from search result lists or video recommendation lists. If necessary, the searcher must move on to subsequent searches after an assessment, during which the searcher may be required to modify techniques, adjust keywords

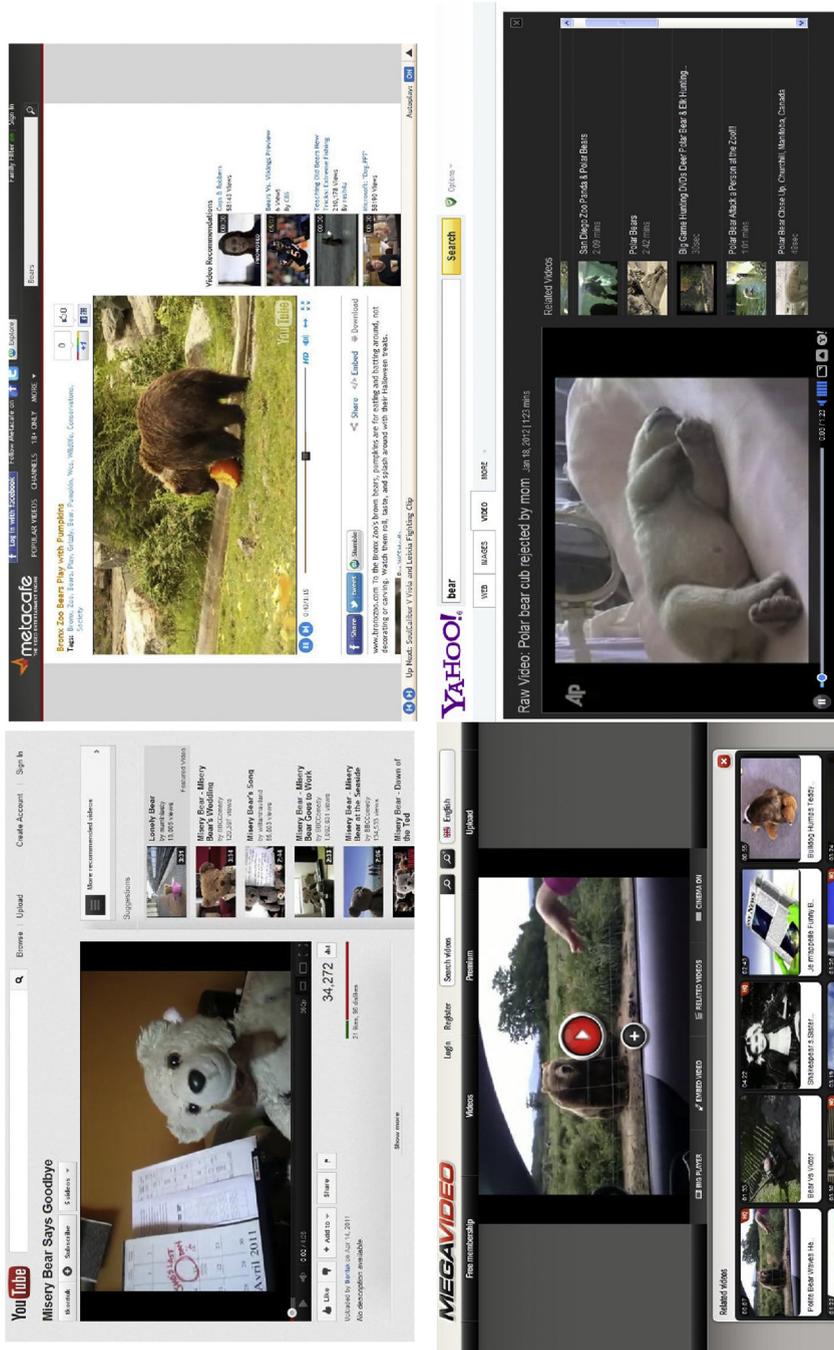


Fig. 1. Examples of video search engines.

Table 1

The similarities and differences between the three types of search engines.

	Text search	Image search	Video search
Input	Keywords	Keywords	Keywords
Output	Texts	Images	Videos
Information presentation	Printed text	Static photos/pictures	Dynamic graphics/motion pictures, printed text, speech text
Search result	Open answers	Open answers	Open answers
Distinctive processes	Not specified	Image-text cross-referencing, observation, judgment, decision-making, and correction	Visual channel and verbal channel operate at the same time
Distinctive functions	Not specified	Not specified	Video recommendation system
Prerequisites for search	Reading comprehension skills	Visual literacy	Absorbed in the information of many different formats such as images, words, and audio sounds
Representative search engines	Google, Yahoo	Google Image, Yahoo! Image search	YouTube, Google Video

or rephrase questions to better achieve the desired purpose. The entire search process comprises planning, monitoring, evaluating, and revising activities. These are metacognitive learning strategies (planning, monitoring, and evaluating strategies; [Brown, 1987](#)) and also a self-regulated learning process (planning, practice, and evaluation; [Zimmerman, 1995](#)). Planning a search and understanding the search tasks are highly related to “planning”. Entering keywords and watching videos are part of “monitoring/practice”. Comparing and selecting relevant videos refer to “evaluation”. Therefore, we believe that metacognitive strategies are the critical roles for video search. How users' metacognition influences their search behaviors and performance, however, is not well understood. Therefore, investigating whether metacognitive skills are key influencers in the course of video search and how they influence one's search and learning processes are the main goals of this study.

In terms of media features, videos include symbolic (such as visual text or auditory text), imagery (such as pictures and animations), and vocal (such as music and sound) messages. How each of these messages integrates with the others and is used by individuals is also important for us to understand students' cognitive and search processes. Some people are more advanced in handling words, whereas others show better performance in handling images ([Mayer & Massa, 2003](#)). Each individual has a preference for words or imagery that results from the varying amount of time required for them to process nonverbal and verbal symbols. Videos include both of these types of knowledge representation. Subject lines, summaries, thumbnails, and the type of information provided by search engines as well as the narration, animations, and subtitles in videos are all very important information for users (including viewers and those searching for information). When different users are exposed to video, do they prefer verbal or visual representations? Which representation can users process more efficiently? This study adopts [Riding and Cheema \(1991\)](#)'s verbal-imagery cognitive style (VICS) to investigate this issue because VICS may be related to the speed of the encoding process referred to by [Paivio's \(1971, 1986\)](#) dual-coding theory (DCT). Does students' cognitive style make a difference in their search behaviors and performance? This study also addresses this question.

2. Literature review

2.1. Individual differences in web searches

Information searches are considered complex cognitive processes ([Hsieh-Yee, 2001](#); [Rouet, 2003](#); [Walraven et al., 2008](#)). The process of information seeking is not linear; instead, there are multiple steps that require many actions. Some of the steps require repetitive execution and sometimes require continuous trial-and-error until confirmation of the search results ([Brand-Gruwel, Wopereis, & Vermetten, 2005](#)). Individuals may adopt different methods and sequences in seeking information on the same subjects because of the differentiation of individual characteristics and the degree of development of one's cognitive abilities ([Albertson, 2010b](#); [Bilal & Kirby, 2002](#); [Bronstein, 2014](#); [Ford, Eaglestone, Madden, & Whittle, 2009](#); [Ford, Miller, & Moss, 2005](#); [Hsieh-Yee, 2001](#); [Kao, Lei, & Sun, 2008](#); [Kim, 2008](#); [Kim & Allen, 2002](#); [Laxman, 2010](#); [Lei, Kao, Lin, & Sun, 2009](#); [Park & Black, 2007](#); [Rouet, 2003](#); [Sun et al., 2014](#); [Zhou, 2014](#)). For example, reading multiple pages of search results in detail versus skimming one page of results before trying a new keyword, following multiple links versus stopping after the first webpage, and utilizing one versus multiple search engines. Different individuals thus achieve different search outcomes and experience different learning effects.

Regarding differences in search behaviors and performance, researchers have looked at individual factors, such as personal experiences (e.g., background, gender, Internet experience, and familiarity), personal cognition (e.g., domain knowledge, reading skill, spatial ability, problem-solving ability, metacognition, and understanding of the search task), personal approaches (e.g., study approaches, perceptions of and preferred approaches to web-based information seeking, thinking style, and cognitive style), environmental factors (e.g., search engines and metadata), and task types (e.g., locating websites versus locating information, closed-ended versus open-ended) ([Albertson, 2010b](#); [Allen, 1998, 2000](#); [Bilal & Kirby, 2002](#); [Brand-Gruwel et al., 2005](#); [Chiu, 2006](#); [Choi, 2010](#); [Ford et al., 2005](#); [Hsieh-Yee, 2001](#); [Kao et al., 2008](#); [Kim, 2008](#); [Kim & Allen, 2002](#); [Lei et al., 2009](#); [Lei, Lin, & Sun, 2013](#); [Park & Black, 2007](#); [Rouet, 2003](#); [Sun et al., 2014](#); [Zhou, 2014](#)). These studies

demonstrate that despite constant advancement in the platform and index of search engines, the individual differences between users still play a crucial role in determining the success of a search.

2.2. Metacognition

Metacognition is used as a hypernym encompassing the structures that are related to individuals' thinking processes and information-gathering mechanisms (Leader, 2008). For example, metacognitive beliefs, metacognitive awareness, metacognitive experiences, metacognitive knowledge, feeling of knowing, judgment of learning, metamemory, metacognitive skills, metacomponents, metacognitive strategies, learning strategies, heuristic strategies, and self-regulation are all terms that are associated with metacognition (Akturk & Sahin, 2011; Veenman, Van Hout-Wolters, & Afflerbach, 2006; Zimmerman, 1995). Metacognition is defined as "cognition about cognition" or "knowing about knowing" (Metcalfe & Shimamura, 1994); it occurs as a result of individual evaluation and observation of cognitive behavior in a learning environment (Ayersman, 1995). Therefore, metacognitive activities usually occur before cognitive activities (planning), during such activities (monitoring) or after the activities (evaluating) (Akturk & Sahin, 2011).

Metacognitive learning strategies involve individuals' planning of their own and others' cognitive processes before they fulfill a task, observing their thinking, learning and understanding while performing the task, controlling and regulating their thinking by making arrangements on site, and evaluating after they have completed their task (Akturk & Sahin, 2011; Scott, 2008). The processes of Web information retrieval entail planning appropriate search strategies, monitoring progress, and evaluating search results. These behaviors are associated with metacognitive learning strategies (Brown, 1987; Israel, 2007). Therefore, this study aims to provide a deeper understanding and clarification of the connection between individual differences in metacognitive strategies and search behaviors, search performance, and learning performance.

2.3. Verbal-imagery cognitive style

Some researchers argue that cognitive styles are critical factors that influence learning performance, especially in the development of hypermedia-based learning (Park & Black, 2007; Rezaei & Katz, 2004; Riding & Rayner, 1998). Cognitive styles refer to an individual's preferred and habitual ways of organizing, processing, and representing information (Riding & Rayner, 1998). A number of different labels have been given to cognitive styles, although many of them are simply different conceptions of the same dimensions (Riding & Sadler-Smith, 1992). Riding and others have designed many different psychological experiments based on individuals' cognitive style model to understand the relationship between cognitive styles and the representation of learning materials. Riding and Cheema (1991) surveyed approximately 30 different cognitive styles and concluded that most of them can be grouped into two basic style dimensions—the verbal-imagery dimension (which indicates a preference for processing information using pictures or words) and the wholistic-analytic dimension (which indicates a preference for information structured so as to understand the whole concept or its details). Because locating videos from the YouTube search engine involves verbal and visual information, including watching video frames and subtitles, hearing narration, and reading text descriptions by the uploaders, this study investigates the possible influences of the verbal-imagery cognitive style on video search behaviors, search performance, and learning performance.

3. Method

3.1. Present study

This study focuses on the effect of learners' metacognitive strategies and cognitive style on their video search behaviors, search performance and learning performance. In terms of metacognition, Brown's (1987) perspectives on planning, monitoring and evaluating strategies were adopted, and Riding and Cheema (1991) ideas on "verbal-imagery" cognitive styles were employed. The popular and mature platform "YouTube" was used to investigate how learners locate the videos they need. Participants were asked to search for videos related to natural science teaching materials. CamStudio was used to record screen displays in real time to capture users' search processes (qualitative data). After watching the videos, the students were asked to write down knowledge concepts of animal courtship on a worksheet. Following the task completion, the individual search processes were quantified as search behaviors (quantitative data). Three raters (including a computer teacher, an art teacher, and a natural sciences teacher) were asked to individually judge the students' search and learning performance (quantitative data) based on how well the retrieved videos and the completed worksheets matched the topic. Then, we selected several representative participants to observe their search process and conducted interviews to understand their thought process (qualitative data).

A summary of our research design is illustrated in Fig. 2. We established four research questions for this project:

1. Given a specific search task, how do elementary school students perform video searches (search behaviors)? How successful are their video searches (search performance)? How successfully do they acquire knowledge from video searches (learning performance)?

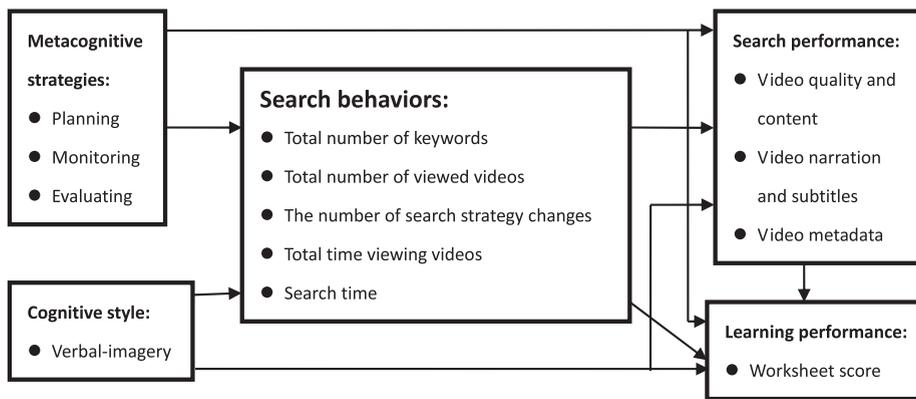


Fig. 2. Main study design.

2. What are the effects of metacognitive strategies (planning, monitoring, and evaluating) and verbal-imagery cognitive style on video search behaviors, search performance, and learning performance? We collected quantitative indicators of search behaviors and qualitative observational descriptions of the search process.
3. What are the effects of video search behaviors on search and learning performance?
4. What are the effects of video search performance on learning performance?

3.2. Participants

Study participants were 100 fifth graders (48 boys, 52 girls) from three classes in an elementary school located in central Taiwan. The sample consisted of students that were in normal groupings. Students with identifiable learning disabilities were excluded. Students had practiced their basic computer and web literacy skills and knew, at a minimum, how to use word processors, simple graphics programs, Power Point, email programs, and web browsers. Many students had used YouTube to watch movies in a computer course. Participants understood the interfaces of the search engines.

3.3. Measures

3.3.1. Metacognitive strategy use questionnaire

According to Brown (1987), the metacognitive strategy use questionnaire (MSUQ) consists of three subscales: planning, monitoring, and evaluating strategies. This study adopted Chiu's (2006) MSUQ, which was modified from Lin's (2002) MSUQ. The questionnaire consists of 30 items (7 items for planning strategy, 16 for monitoring strategy, and 7 for evaluating strategy). All of the items on this questionnaire are measured on a four-point Likert scale. Chiu (2006) reported that the internal consistency (Cronbach's alpha) of planning strategy was .7429; monitoring strategy, .8184; evaluating strategy, .7346; and the whole scale, .9086; these values were regarded as acceptable. The mean scores of the subscale in our sample were planning, 2.67 (SD = .59); monitoring, 2.80 (SD = .47); and evaluating, 2.93 (SD = .56).

3.3.2. VICS questionnaire

The VICS questionnaire was adopted from Tsai's (2006) Learning Style Questionnaire – Cognitive Preference. It aims to measure students' preference for words or images when they study natural science. Tsai's questionnaire, which includes 11 test items, was modified from Felder and Silverman (1988) Index of Learning Styles Questionnaire. Each item includes two options: A (prefer to learn with image information) and B (prefer to learn with verbal information). The higher the score is, the more the person is inclined to prefer an imagery style; the lower the score is, the more the person is inclined to prefer a verbal style. The internal consistency coefficient in our sample was .71, which was regarded as acceptable. The maximum score for cognitive style in our sample was 11, the minimum score was 1, and the mean score was 5.86 (SD = 2.34). Most participants' scores were concentrated in the zone of normal distribution, and they belonged to the verbal-imagery mixed style.

3.3.3. Search behavior indicators

The following are indicators that quantify learners' search processes as search behaviors. A) The total number of keywords (Cunningham & Nichols, 2008; Lin & Tsai, 2007), which reflects the range of the information search. B) The total number of viewed videos (Cunningham & Nichols, 2008), i.e., the amount of videos that the participants watched on the YouTube interface. We further categorized the videos based on their content and source as follows: (a) the number of viewed relevant videos selected from search result lists, (b) the number of viewed irrelevant videos selected from search result lists, (c) the number of viewed relevant videos selected from video recommendation lists, and (d) the number of viewed irrelevant videos

selected from video recommendation lists. C) The number of search strategy changes, which indicates how many times the participants changed from using “search result list” to “video recommendation lists” or vice versa. D) The total time spent viewing videos, i.e., the amount of time that the participants spent watching videos. We further categorized the time spent watching videos based on their content and source as follows: (a) the time spent viewing relevant videos selected from search result lists, (b) the time spent viewing irrelevant videos selected from search result lists, (c) the time spent viewing relevant videos selected from video recommendation lists, and (d) the time spent viewing irrelevant videos selected from video recommendation lists. E) Search time, which is defined as the time that elapsed from entering the first keyword to finding the target video.

Because several unique behaviors or thoughts of the participants are difficult to observe through quantifiable indicators, qualitative approaches were also used in this research. Thirty individuals were selected from the participants based on different characteristics, including planning skills (5 for strong and 5 for weak), monitoring skills (5 for strong and 5 for weak), and evaluating skills (5 for strong and 5 for weak). Their search processes—for example, the keywords they used, the video contents, and the most frequently used function on the user interface—were carefully recorded. In addition, one participant whose worksheet was scored high and another whose worksheet was scored low were picked among those who preferred an imagery style, and one participant whose worksheet was scored high and another whose worksheet was scored low were picked among those who preferred a verbal style. These four students were interviewed after the search activity to understand what information they reviewed during their search process.

3.3.4. Video search worksheet

The task was defined as follows: We can observe that most animals in the wild exhibit courtship behaviors. For example, fireflies beam lights and frogs croak to attract potential mates. Please search for a video about animal courtship on YouTube and record what you saw in the video.

The grading of the video submitted by the students was divided into 3 parts: (a) video quality and content (whether the topics were definitive, whether the concepts were complete and accurate, and whether the visual effect of the video was clear), which was rated from 0 to 10 points; (b) video narration and subtitles (whether the narration was explicit, whether the sound quality was clear, and whether the subtitles were accurate and complete), which was rated from 0 to 10 points; and (c) video metadata (whether the description of the video provided by the uploader was accurate, explicit and easy to comprehend), which was also rated from 0 to 10 points. The grading of the submitted worksheets also ranged from 0 to 10 points. The grading was based on whether the student specified the animal names, behaviors, and actions. A Kendall coefficient of agreement was used to examine consistency among the three raters; the results indicated a high level of inter-rater reliability on video quality and content ($W = .90, p < .001$), video narration and subtitles ($W = .95, p < .001$), video metadata ($W = .92, p < .001$), and worksheet scores ($W = .85, p < .001$).

3.4. Procedure

Participants performed the task in a computer classroom during a computer course. The study was conducted over two weeks because it required a total of 90 min. The MSUQ and VICS questionnaires were given in week 1 (30 min). The video search task and the worksheet were completed in week 2 (60 min).

4. Results and discussion

4.1. Video search behaviors, search performance, and learning performance

The descriptive statistics for the search behaviors, performance, and learning performance of the participants are shown in Table 2. The participants used an average of 3–4 keywords per search task, and 29.5% of them entered only a single keyword to find the videos they needed. Many students used “courtship” as the first keyword, and the majority added (or deleted) a certain animal name to (or from) the original keyword (e.g., tiger courtship, dog courtship, or frog courtship) when the preceding keyword was unsuccessful.

The participants viewed an average of 3 videos to accomplish their video searches. Four students used up all of the time to watch more than 10 videos, and 35.2% of the participants viewed only one video to acquire the target video. Approximately 77.81% of the videos they viewed were selected from search result lists, and 22.19% were selected from video recommendation lists. Of all the videos from the search result lists, 79.52% were relevant videos (e.g., ostrich courtship), and 20.48% were irrelevant videos (e.g., a guppy produces babies). Of all the videos from the video recommendation lists, 67.60% were relevant videos (e.g., the dancing birds), whereas 32.40% were irrelevant videos (e.g., the pig danced the courtship dance (“Pig” is also a stage name of a famous actor in Taiwan; therefore, this video is a dancing show that is irrelevant to animal courtship.)). The participants changed their search strategies approximately 1 time when the search results did not meet their expectations. The standard deviation statistics of the above variables were very high because some participants did not view irrelevant videos, select videos from video recommendation lists, or change search strategies.

The average time spent watching videos was 222.35 s. Some students spent only 1 or 2 s watching a video and quickly determined that the video was sufficient to answer the inquiries, whereas some students spent more than 300 s watching an entire video from beginning to end. The average time spent on the entire video search process was 647.80 s. This finding

Table 2

Descriptive statistics for search behaviors, search performance, and learning performance (N = 100).

Variable	Mean	SD	Minimum	Maximum
Search behaviors:				
Total# keywords	3.78	3.19	1	16
Total# viewed videos	3.20	2.31	1	13
# Viewed relevant videos selected from search result lists	1.98	1.50	0	6
# Viewed irrelevant videos selected from search result lists	.51	.88	0	3
# Viewed relevant videos selected from video recommendation lists	.48	.96	0	4
# Viewed irrelevant videos selected from video recommendation lists	.23	.52	0	4
# Search strategy changes	.61	.75	0	4
Total time spent viewing videos	222.35	228.97	0	830
Time spent viewing relevant videos selected from search result lists	94.33	137.63	0	830
Time spent viewing irrelevant videos selected from search result lists	48.00	75.48	0	283
Time spent viewing relevant videos selected from video recommendation lists	42.51	81.51	0	183
Time spent viewing irrelevant videos selected from video recommendation lists	37.60	92.88	0	396
Search time	647.80	718.56	46	6030
Search performance:				
Video quality and content	5.84	1.97	0	10
Video narration and subtitles	2.03	2.96	0	10
Video metadata	3.10	2.48	0	10
Learning performance:				
Worksheet score	6.67	1.92	1.67	10

indicates that in addition to watching videos, students spent considerable time on other actions, such as entering keywords, pondering what to do next, or waiting for a video clip to stream.

The mean scores of the video quality and content, video narration and subtitles, and video metadata were 5.84 (SD = 1.97), 2.03 (SD = 2.96), and 3.10 (SD = 2.48), respectively. Most of the participants found relevant videos as the target videos; however, a large proportion of these videos lacked not only asides or subtitles but also explicit descriptions on the video retrieval interfaces. Therefore, the scores for the video narration and subtitles and video metadata were low. The mean score for the worksheet was 6.67 (SD = 1.92). Most of the participants could write down the animal names correctly but could not interpret the courtship behaviors completely.

4.2. Effects of metacognitive strategies and VICS on video search behaviors, search performance and learning performance

The results of the data pertaining to correlations are shown in Table 3. Significant correlations were found between the planning strategy and the total number of keywords ($r = -.212$, $p < .05$), the total time spent viewing videos ($r = -.236$, $p < .05$), the time spent viewing irrelevant videos selected from video recommendation lists ($r = -.272$, $p < .05$), video

Table 3

The coefficient of the correlation between video search and learner characteristics.

Video search	Learner characteristics			
	Metacognitive strategies			Cognitive style
	Planning	Monitoring	Evaluating	
Search behaviors:				
Total# keywords	-.212*	-.202	-.252*	-.053
Total# viewed videos	-.197	-.141	-.272*	.164
# Viewed relevant videos selected from search result lists	-.008	.018	-.116	.120
# Viewed irrelevant videos selected from search result lists	-.081	-.067	-.130	-.033
# Viewed relevant videos selected from video recommendation lists	-.088	-.024	-.171	.081
# Viewed irrelevant videos selected from video recommendation lists	-.142	-.202	-.251*	.246*
# Search strategy changes	-.155	-.143	-.263*	.117
Total time spent viewing videos	-.236*	-.117	-.321**	.191
Time spent viewing relevant videos selected from search result lists	-.117	-.066	-.117	.220*
Time spent viewing irrelevant videos selected from search result lists	-.101	.022	-.017	.009
Time spent viewing relevant videos selected from video recommendation lists	-.206	-.115	-.235*	-.049
Time spent viewing irrelevant videos selected from video recommendation lists	-.270*	-.211*	-.272*	.128
Search time	-.136	-.021	-.056	.160
Search performance:				
Video quality and content	.088	.062	.111	.099
Video narration and subtitles	.041	-.032	-.058	.117
Video metadata	.301**	.231*	.168	.177
Learning performance:				
Worksheet score	.228*	.203	.237*	.073

*: $p < .05$, **: $p < .01$.

metadata ($r = .301, p < .01$), and the worksheet score ($r = .228, p < .05$). Students with better planning skills tended to use fewer keywords in the search process, take less time to view and evaluate videos (particularly irrelevant videos selected from video recommendation lists), choose videos with more explicit metadata information, and obtain higher scores on the worksheets. According to these data, the search process observations, and the interviews, we found that students with better planning skills found a way to understand the video content by reading the information on the search engine interface before deciding whether they wanted to watch a video. They carefully reviewed the thumbnails on the side or the descriptions next to the videos when selecting films, and they chose to watch videos that had more detailed descriptions. Because some video providers have inscribed complete information (for example, the red-crowned cranes in Red Mountain Zoo in Nanjing, Jiangsu province, are in the midst of mating season, so they jump and make “ge” noises to attract the attention of their potential mates ...), students with better planning skills utilized these descriptions or thumbnails to search for appropriate videos without inputting keywords repetitively. Thus, they could reduce the number of keywords they used. In addition, because they read the descriptions of the videos, they already knew about their content. They controlled the timeline of the videos and skipped irrelevant parts to watch the most important parts, thus saving time watching the videos and finding more relevant films quickly. Furthermore, they did not waste time watching irrelevant videos on the video recommendation lists because they already knew that those videos were not pertinent to the task. Meanwhile, they were able to understand animal courtship behavior and scored higher on the worksheets from text descriptions (such as answering the questions on the worksheet from the descriptions) and video content (such as taking notes while watching the video).

Significant correlations were found between the monitoring strategy and both the time spent viewing irrelevant videos selected from video recommendation lists ($r = -.211, p < .05$) and video metadata ($r = .231, p < .05$). Students with better monitoring skills tended to take less time viewing irrelevant videos selected from video recommendation lists and choose videos with more explicit metadata information. According to these data, the search process observations, and the interviews, we found that students with better monitoring skills tried to search for videos with summaries and understood the video content before watching it. Furthermore, they did not waste much time watching videos that were irrelevant to their task.

Significant correlations were found between participants' evaluating strategy and the total number of keywords ($r = -.252, p < .05$), the total number of viewed videos ($r = -.272, p < .05$), the number of viewed irrelevant videos selected from video recommendation lists ($r = -.251, p < .05$), the number of search strategy changes ($r = -.263, p < .05$), the total time spent viewing videos ($r = -.321, p < .01$), the time spent viewing relevant videos selected from video recommendation lists ($r = -.235, p < .05$), the time spent viewing irrelevant videos selected from video recommendation lists ($r = -.270, p < .05$), and the worksheet score ($r = .237, p < .05$). Students with better evaluating skills tended to use fewer keywords in the search process, view fewer videos (particularly for irrelevant videos selected from video recommendation lists) when browsing the search results, have fewer search strategy changes, take less time to view and evaluate videos (including relevant and irrelevant videos selected from video recommendation lists), and obtain higher scores on the worksheet. According to these data, the search process observations, and the interviews, we found that students with better evaluating skills were more cautious in assessing which keywords they wanted to use before searching for their videos; therefore, they performed better when inputting or adjusting keywords (for example, most of these students typed in “animal courtship” as keywords) and did not aimlessly try many combinations of keywords. They had fewer keyword attempts than others because their keywords were usually more precise and had an explicit target. They were able to quickly find videos from search result lists. Most of them did not use the YouTube video recommendation lists. In other words, they could find their target videos without changing their searching strategies, and they did not aimlessly watch useless videos. In addition, most of them did not view entire videos. Some participants watched only fragments of the first part, whereas others selected clips randomly by dragging the bar. All they had to do was watch fragments of videos to decide which ones they needed because they had very clear targets in mind. They did not spend much time watching one video after another regardless of their relevance to the task. Although they spent less time watching videos, they still grasped the essence of the content and then picked the right video and recorded accurate information because they took notes on the important clips. They fully understood what the videos were trying to convey; thus, they scored higher on the worksheet.

Significant correlations were found between cognitive style and both the number of irrelevant videos viewed that were selected from video recommendation lists ($r = .246, p < .05$) and the time spent viewing relevant videos that were selected from search result lists ($r = .220, p < .05$). Students who preferred to learn with image information tended to view more irrelevant videos selected from video recommendation lists and took considerable time to view relevant videos selected from search result lists. These results indicate that students who tended toward an imagery style actually prefer to learn with image information. They like to watch a variety of videos regardless of whether the concepts of the retrieved videos meet the task requirements.

Furthermore, we used a multiple regression analysis (stepwise method) to clarify the relative predictive powers of participants' individual characteristics (metacognition and cognitive style) on their search behaviors, search performance and learning performance. According to our results, the evaluating strategy accounted for 6.4% of the variance in the total number of keywords ($R^2 = .064, F = 5.835, p < .05$). Specifically, the evaluating strategy was a negative predictor of keyword usage ($\beta = -.252, t = -2.416, p < .05$). The evaluating strategy accounted for 7.4% of the variance in the total number of viewed videos ($R^2 = .074, F = 6.875, p < .01$). Specifically, it was a negative predictor of viewing the search results ($\beta = -.272, t = -2.622, p < .01$). The evaluating strategy accounted for 6.3% of the variance in the number of viewed irrelevant videos selected from video recommendation lists ($R^2 = .063, F = 5.768, p < .05$). Specifically, it was a negative predictor of viewing irrelevant search results ($\beta = -.251, t = -2.402, p < .05$). The evaluating strategy accounted for 6.9% of the variance in the

number of search strategy changes ($R^2 = .069$, $F = 6.406$, $p < .05$). Specifically, it was a negative predictor of changing search strategies ($\beta = -.263$, $t = -2.531$, $p < .05$). The evaluating strategy accounted for 10.3% of the variance in the total time spent viewing videos ($R^2 = .103$, $F = 9.905$, $p < .01$). Specifically, it was a negative predictor of the time spent viewing and evaluating search results ($\beta = -.321$, $t = -3.147$, $p < .01$). The cognitive style accounted for 4.8% of the variance in the time spent viewing relevant videos selected from search result lists ($R^2 = .048$, $F = 4.356$, $p < .05$). Specifically, it was a positive predictor of the time taken to view relevant search results selected from search result lists ($\beta = .220$, $t = 2.087$, $p < .05$). The evaluating strategy accounted for 5.5% of the variance in the time spent viewing relevant videos selected from video recommendation lists ($R^2 = .055$, $F = 4.978$, $p < .05$). Specifically, it was a negative predictor of the time taken to view relevant search results selected from video recommendation lists ($\beta = -.235$, $t = -2.231$, $p < .05$). The evaluating strategy accounted for 7.4% of the variance in the time spent viewing irrelevant videos selected from video recommendation lists ($R^2 = .074$, $F = 6.789$, $p < .05$). Specifically, it was a negative predictor of the time taken to view irrelevant search results selected from video recommendation lists ($\beta = -.272$, $t = -2.605$, $p < .05$). A two-factor model accounted for 13.2% of the variance in video metadata ($R^2 = .132$, $F = 6.436$, $p < .01$). The strongest predictor was the planning strategy ($\beta = .317$, $t = 3.130$, $p < .01$), followed by the monitoring strategy ($\beta = .203$, $t = 2.005$, $p < .05$). The evaluating strategy accounted for 5.6% of the variance in the worksheet score ($R^2 = .056$, $F = 5.102$, $p < .05$). Specifically, it was a positive predictor of learning performance ($\beta = .237$, $t = 2.259$, $p < .05$). Individual characteristics did not account for other search behaviors and performance.

Our data show that video search success was more likely for students with greater capacities for metacognitive strategies. These findings are roughly in line with Chiu's (2006) research on text searches. In particular, when some of the videos were large and slowed down the Internet connection, the videos became difficult to watch because of the interrupted signals. Under this circumstance, the students with greater metacognitive strategies were still able to do a good job, particularly the students with better evaluating strategy. The evaluating strategy had an influence on eight video search indicators, while planning and monitoring strategies only influenced students' reading of video metadata. In other words, the evaluating strategy was a more influential factor for video search behaviors and learning performance.

Cognitive style could not account for video search behaviors, search performance, and learning performance. These findings differ from Graff's (2005) study, which showed that cognitive style (verbalizer and imager) influenced browsing patterns on general text searches. One reason for this result could be that multimedia videos on the Internet provide not only image information but also narration and/or subtitles that help viewers understand their content. In addition, the YouTube interface provides the titles of the films, descriptions, keywords and reviews from other viewers to fill the gaps of the video itself. Users can read the descriptions next to the videos to select the one they want to watch. The two participants who preferred the verbal style focused on the texts when reading the search result lists. However, when there was no subtitle or narration in the film, one student who scored higher on the worksheets could nonetheless extract accurate information from the images in the video. Another student who scored lower failed to understand the meaning of this type of video. In addition, one participant who preferred an imagery style and scored higher on the worksheets could grasp the keywords in the task and knew how to use texts with images when reading the search result lists. Another student who preferred an imagery style and scored lower deviated from the theme and searched for videos using keywords such as "fireflies", "Hercules beetles" and "butterflies", ignoring the core concept of "courtship". Additionally, he did not like to read the texts in the search result lists, and he made judgments based only on thumbnails. Therefore, the videos he found did not meet the task requirements. From the interviews, we learned that learners should still absorb information from many different formats, such as images, words, and audio sounds, to ensure that they receive all the necessary messages to make their own judgment and achieve better search and learning performance. If they focus only on the formats that they prefer and miss other information, the effectiveness of their search and their learning tend to be poorer.

4.3. Effects of video search behaviors on search and learning performance

The correlation results show that significant negative correlations were found between the total number of keywords and video quality and content ($r = -.229$, $p < .05$), video narration and subtitles ($r = -.248$, $p < .05$), and the worksheet score ($r = -.336$, $p < .01$). The fewer keywords the students used to search for videos, the better performance they acquired on both the videos and worksheets. Based on our observations, the students who only inputted one keyword and were able to achieve an above-average search performance used "animal courtship" or "courtship behaviors" as keywords. They were able to find related films quickly and did not need to repeat their searches because these keywords led them to find all types of animal courtship videos. That is, participants who could grasp the core concept of the tasks showed better performance in search and learning effectiveness.

These results are contrary to those reported by Tu (2005) for text searches and are not consistent with those reported by Lei et al. (2013) for image searches. Tu found positive relationships between search performance and both the total number of keywords and the average number of Chinese characters per keyword. Lei, Lin and Sun found positive relationships between search performance and two search behavior indicators associated with text-image coherence, but no relationship was found between performance and keyword-based indicators. We believe the difference lies in the distinction between text, image and video searches. The total number of keywords implies variations in the search for information (Tu, 2005). Because it is easy in text search for users to employ related ideas to formulate keywords, they can broaden or narrow search scope by constantly changing the keywords. Moreover, text search has a huge database; therefore, it takes users only a few searches to retrieve the

correct documents or answers. However, given that images generally have abstract and complex concepts, it is harder for users to translate their visions into literal descriptions to formulate keywords. Therefore, sometimes, search engines may not provide the corresponding images. Under this circumstance, it is vital for users to compare and evaluate the relevance of images based on the task description. Users will obtain better search performance if they are more willing or able to view more pages of image search results. In video search, not every topic is suitable to be made into a video; therefore, the database of videos is not as enormous as that of images or texts. For example, some animals do not have obvious courting behaviors. Obviously, it would be hard to find related films for these animals. However, students who did not understand this concept kept inputting keywords such as “dogs’ courtship”, “cats’ courtship”, “crocodiles’ courtship”, “pandas’ courtship” and “bats’ courtship” and thus failed to find appropriate films. In addition, many films on YouTube are homemade videos that do not have a purpose. Some of them do not have well-defined topics. They may be blurry or lack subtitles, narrations or descriptions. Some students did not even know that the behaviors of some animals in the films were courtship behaviors, so even though they kept trying different keywords and watched more videos than others, they still failed to succeed in the task. They simply were not aware that the answer was staring right at them. Of course, online videos will not help them learn anything. Moreover, some students mistook “mating” to mean “courtship”, so they typed in “animal mating”, “lions mating”, “zebras mating”, “elephants mating” or “ostriches mating”. The films they found were not compliant with the task requirements. Therefore, if the students failed to use accurate keywords, they were not able to find relevant videos, and changing keywords frequently did not help to resolve the issue. In summary, users must adopt different search strategies when using various types of search engines (text, image, map or video) to excavate the correct information that fulfills their needs.

The correlation results show significant positive correlations between the video metadata and the total number of viewed videos ($r = .253, p < .05$), the number of viewed relevant videos selected from search result lists ($r = .362, p < .01$), and the number of viewed relevant videos selected from video recommendation lists ($r = .324, p < .01$). The more videos (particularly relevant videos) the students watched, the better videos (with explicit metadata information) they retrieved. These results show that the students had more opportunities to evaluate whether each film was applicable after watching more videos. They also had more opportunities to obtain videos with more elaboration, and these videos helped them understand the key concepts.

The correlation results show significant negative correlations between the worksheet score and both the number of viewed irrelevant videos selected from video recommendation lists ($r = -.240, p < .05$) and the time spent viewing irrelevant videos selected from video recommendation lists ($r = -.211, p < .05$). As the amount of time the students took to watch irrelevant videos selected from video recommendation lists increased, their learning performance decreased. Video recommendation lists are based on the videos that general users watch on a search engine; therefore, sometimes, these videos are not related to the original search targets. However, they are usually very interesting, which is why they have higher viewership. They can easily capture the eye of students. As a result, some students watched many videos that were unrelated to the task. For example, some students chose “peacock’s courtship dance” from search result lists when they used “courtship” as keyword. In that case, they saw “the pig danced the courtship dance” on the video recommendation list (this video is a dancing show of a singer in Taiwan). If a student clicked this video, then he or she would see more dancing and singing shows of other artists on their video recommendation lists. Some students wasted extensive time watching these shows. Two students used “dogs’ courtship” as a keyword and selected “The Great Adventure of a Dog and a Monkey” (a Japanese TV show with funny videos – 10 episodes in total) from the search result lists. In this case, they saw other episodes of the same show on the video recommendation lists and kept watching one after another. One student used “The courtship behaviors of dogs” as a keyword, and he watched some video clips by random people who had filmed their dogs at home. He also saw “Home Alone for Animals” (another Japanese show with funny videos about animals – several episodes in total) on the recommendation list, and he watched 3 episodes before going back to search for videos related to the task. Obviously, if a video recommendation list includes many interesting but unrelated videos, students may waste too much time watching these videos. In this scenario, online videos were not helpful for the students in achieving the original learning goals.

Furthermore, we used a multiple regression analysis (stepwise method) to clarify the relative predictive powers of participants’ search behaviors on their search and learning performance. According to our results, the total number of keywords accounted for 4.6% of the variance for video quality and content ($R^2 = .046, F = 4.067, p < .05$). Specifically, it was a negative predictor of search performance ($\beta = -.214, t = -2.017, p < .05$). A two-factor model accounted for 17.1% of the variance in video metadata ($R^2 = .171, F = 8.649, p < .001$). The strongest predictor was the number of viewed relevant videos selected from search result lists ($\beta = .389, t = 3.875, p < .001$), followed by the total number of keywords ($\beta = -.208, t = -2.074, p < .05$). The total number of keywords accounted for 10.6% of the variance in the worksheet score ($R^2 = .106, F = 10.070, p < .01$). Specifically, it was a negative predictor of learning performance ($\beta = -.325, t = -3.173, p < .01$). Other search behavior indicators did not account for search and learning performance. The results show that keyword usage was an important factor that influenced the video search and learning success. In terms of video search, if the students could fully understand the core concepts of their task under the condition that the source of the videos is scarce, they would be able to acquire knowledge about “courtship” using very few and precise keywords.

4.4. Effects of video search performance on learning performance

The correlation results show significant positive correlations between the worksheet score and video quality and content ($r = .332, p < .01$), video narration and subtitles ($r = .302, p < .01$), and video metadata ($r = .319, p < .01$). As the quality of the

videos the students watched improved, so did their learning performance. These results show that finding better videos (including, e.g., conspicuous courtship behaviors, clear visual presentations, abundant verbal information, and explicit descriptions) can assist students in acquiring knowledge of animal courtship.

Furthermore, we used a multiple regression analysis (stepwise method) to clarify the relative predictive powers of search performance on learning performance. According to our results, a two-factor model accounted for 21.7% of the variance in learning performance ($R^2 = .217$, $F = 11.748$, $p < .001$). The strongest predictor was video quality and content ($\beta = .339$, $t = 3.527$, $p < .001$), followed by video metadata ($\beta = .327$, $t = 3.402$, $p < .001$). Video narration and subtitles did not account for learning performance using YouTube. Instead, meaningful learning depends on finding videos with relevant content, readily understandable visual representations, and explicit descriptions from uploaders.

4.5. Conclusions

This study explored how human factors influence search behaviors, search performance, and learning performance in using video search engines. Our findings indicate that video search success is dependent on metacognitive strategies (a cognitive factor). Students with better evaluating and planning abilities could locate the videos that fulfilled the task requirements by using accurate keywords or reading video metadata information. They achieved better learning performance because they understood more about the process of animal courtship. However, cognitive styles (an affective factor) did not have a strong influence on video searches. The results support the conclusion that cognitive factors significantly influenced search behaviors and performance. These results are consistent with those reported for various types of search engines in previous studies: (a) in terms of text search, domain knowledge (a cognitive factor) affected search precision but cognitive style—analytical or intuitive (an affective factor)—did not have an effect (Park & Black, 2007); (b) successful image searches are strongly dependent on reading ability (a cognitive factor) rather than on Internet experience (a skill factor) (Lei et al., 2013); (c) the strongest predictor of landmark search performance is environmental cognition (a cognitive factor), followed by spatial ability and geographic knowledge (two cognitive factors) (Lei et al., 2009). In sum, compared with affective and skill factors, cognitive abilities play a more important role in web information retrieval. Therefore, the development of cognitive abilities is very important for students to be able to search the web for information effectively.

In addition to individual characteristics, search behaviors and strategies can serve as indicators of how students interact with and respond to search engine interfaces. As discussed in Chapter 4.3, the search behaviors regarding the aspect of keyword usage in this study are different from those for text and image searches. As a result, we can conclude that there are indeed some differences in the nature of video searches and text/image searches. Users must adopt different search strategies when using various types of search engines.

One aspect of the results that is worth mentioning is that students with better metacognitive skills easily found relevant videos because they had a definite target in mind about what types of videos might fit their selection criteria when using the video recommendation tools provided by the search engine. On the contrary, students with low metacognitive skills tended to be misled by the system after using the wrong keywords or selecting irrelevant videos from the “video recommendation lists”. They might have lost focus on their original targets and wasted time watching irrelevant videos. For this reason, when working on new products and exploring specialized technologies aimed at various types of information embedded in websites and in the unique features of Web 3.0 semantic content tagging, search engine developers need to understand how users construct mental representations, how complex information negatively affects performance, and how to alleviate users' working memory loads when performing video searches. Future search technologies should consider offering more personalized functions in terms of inquiry strategies, filtering techniques, and multimedia indexing. For example, search engines could provide some functions that can be enabled or disabled based on users' inclinations. However, it remains to be examined whether these new functions would support greater search result accuracy or simply impose additional cognitive burdens.

The task used in this study was designed based on a natural science class. Hopefully, this research can help students experience “using the Internet to better assist them in learning their textbook knowledge by searching for relevant videos online”. Videos can serve as an effective tool to help students learn more about the progress of something and learn better by providing them a strong impression of the learning materials. However, videos are infused with complex concepts. It is sometimes hard for people to describe the video content that they want using accurate keywords. In addition, many videos on websites are uploaded randomly by Internet users, so video quality is uneven. Moreover, the database of instructional videos is not as enormous as that of images or texts; therefore, it does not have enough videos for users to select, evaluate, and compare in some topics. To help students achieve autonomous learning, educators must focus on teaching Internet search and website information assessment skills, particularly the skills of constructing keywords, and helping students acquire the knowledge contained in various types of search engines. Teachers should provide different guidance to students based on their individual differences and encourage them to use their characteristics and expertise to acquire good, readable information from the Internet. Only by motivating students to take the initiative to seek and construct their own knowledge pool and become adept at searching, processing and evaluating information will they be able address all types of tasks and problems in real life.

We acknowledge at least two study limitations. First, the findings from this research may not be applicable to text and image searches. Second, the author adopted the model-driven methodology to explore individual differences in search behaviors and performance measured through various questionnaires. Future research could further adopt the data-driven

methodology to investigate individual characteristics in accordance with search behavior patterns collected through artificial intelligence technologies. Thus, the results of these two methods could be cross-referenced, which would enhance the accuracy of this study.

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