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Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness

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Abstract

Interactive video in an e-learning system allows proactive and random access to video content. Our empirical study examined the influence of interactive video on learning outcome and learner satisfaction in e-learning environments. Four different settings were studied: three were e-learning environments—with interactive video, with non-interactive video, and without video. The fourth was the traditional classroom environment. Results of the experiment showed that the value of video for learning effectiveness was contingent upon the provision of interactivity. Students in the e-learning environment that provided interactive video achieved significantly better learning performance and a higher level of learner satisfaction than those in other settings. However, students who used the e-learning environment that provided non-interactive video did not improve either. The findings suggest that it may be important to integrate interactive instructional video into e-learning systems.

Keywords: E-learning; Interactive video; Learning effectiveness

1. Introduction

Learning provides "intellectual growth that leads to scientific reasoning, abstract thought, and formal operations" [36]. As information technologies like virtual workspaces and digital libraries have evolved, they have added new environments for teaching and learning and have given rise to new areas for research.

Learning enhanced by information technologies is gaining momentum. This is partially in response to the demand for reduction in time-to-competency in the knowledge-based economy, spurred by intensive competition and globalization. Companies need to offer effective training to employees and business partners to ensure that they acquire new skills in a timely manner. In academia, education must be

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delivered to remote students who do not have physical access to the campus.

E-learning has recently become a promising alternative to the traditional classroom learning, helping society move toward a vision of lifelong and on-demand learning [56]. It has become one of the fastest-moving trends [51] and aims to provide a configurable infrastructure that integrates learning material, tools, and services into a single solution to create and deliver training or educational content quickly, effectively, and economically [37]. Thousands of online courses are now being offered. Not only can instructional material be made available on the Internet but online collaborative learning and discussions can also occur.

Video is a rich and powerful medium being used in e-learning. It can present information in an attractive and consistent manner. Prior studies have investigated the effect of instructional video on learning outcomes [47]. However, the instructional video used in early studies was primarily either broadcasted through TV programs or stored on CD-ROMs. The linear nature of such video instructions produced inconsistent results [24].

Recent advances in multimedia and communication technologies have resulted in powerful learning systems with instructional video components. The emergence of non-linear, interactive digital video technology allows students to interact with instructional video. This may enhance learner engagement, and so improve learning effectiveness. A major 'media attribute' of interactive video is random access to video content [45]—users can select or play a segment with minimal search time. The concept is not new but is taking on new forms. However, the effect of interactive video on e-learning is still not well understood.

In our research, we mainly focused on investigating the impact of interactive video on e-learning effectiveness through an empirical study. Learning by asking (LBA), a multimedia based e-learning system, integrates multimedia instructional material including video lectures, PowerPoint slides, and lecture notes. The LBA system promotes high levels of interaction by allowing learners to access individual video segments directly. In our empirical study, there were four different learning settings:

1. an e-learning environment with interactive video;
2. an e-learning environment with non-interactive video;
3. an e-learning environment without instructional video; and
4. the traditional classroom.

The learning outcomes and levels of learning satisfaction in each setting were collected and analyzed to yield a better understanding of how interactive video can be used to improve e-learning.

2. Theoretical foundation

2.1. Constructivist learning theory

Constructivists view learning as a formation of abstract concepts in the mind to represent reality. They posit that learning occurs when a learner constructs internal representations for his or her unique version of knowledge [50]. Constructivism argues that interactive activities in which learners play active roles can engage and motivate learning more effectively than activities where learners are passive. Individuals are assumed to learn better when they discover things by themselves and when they control the pace of learning [26]. Therefore, it is natural to expect that self-directed, interactive learning would improve learning outcome.

Constructivists put more emphasis on engaging students in the process of learning than on finding a correct answer. Many constructivists call for richer learning environments that contrast with the typical less interactive classroom environments relying on instructors, textbooks, and lectures. Graphics, video, and other media can help by interesting and engaging learners. Brandt [9] suggested that constructivism should be a basis for Web-based learning. Web-based education supported by the constructivist theory should thus enable learners to engage in interactive, creative, and collaborative activities during knowledge construction.

2.2. Cognitive information processing theory

Cognitive information processing theory is an extension of the constructivist model, based on a model of memory. It proposes processes and structures through which an individual receives and stores information and focuses on cognitive processes during learning; these involve processing instructional input to develop, test, and refine mental models until they are sufficiently elaborated and reliable to be effective in novel problem-solving situations. The frequency and intensity with which a student is challenged to process and use instructional input should then determine the pace of learning.

A major assumption of the cognitive learning model is that a learner's attention is limited and therefore selective. With more interactive and richer media available, a learner who prefers an interactive learning style has more flexibility to meet individual needs. Based on this, we assume that an instructional method that provides a greater variety of interactions and richer media should be more effective.

3. E-learning

3.1. Video-supported e-learning

Extensive research has shown that students benefit from e-learning [5,25,39]. Some of the benefits are that it:

- provides time and location flexibility;
- results in cost and time savings for educational institutions;
- fosters self-directed and self-paced learning by enabling learner-centered activities;
- creates a collaborative learning environment by linking each learner with physically dispersed experts and peers;
- allows unlimited access to electronic learning material; and
- allows knowledge to be updated and maintained in a more timely and efficient manner.

Video allows students to view actual objects and realistic scenes, to see sequences in motion, and to listen to narration. The Virtual Classroom project at NJIT uses asynchronous learning networks plus videotaped lectures to evaluate effectiveness of online courses required for bachelor's degrees in information systems and computer science. Students who have completed online courses tended to do as well as those in traditional classrooms, although more online students withdrew or took an incomplete grade. Carnegie Mellon University's just-in-time lecture project (http://www.jitl.cs.cmu.edu) suggests that video-based education and training systems support the same level of teaching and learning effectiveness as face-to-face instruction. A study probed students' learning effectiveness in a Web environment by comparing learning outcome in traditional instruction versus that in an e-learning environment featured with an asynchronous live switched video with PowerPoint presentation stream [33].

Despite previous efforts, several aspects of instructional video in e-learning have not yet been well investigated. A major problem with the use of instructional video has been lack of interactivity [15]. In most e-learning systems, learners cannot directly jump to a particular part of a video. Browsing a non-interactive video is more difficult and time consuming than browsing a textbook, because people have to view and listen to the video sequentially and thus searching for a specific portion remains a linear process.

We here define *interactive video as the use of computer systems to allow proactive and random access to video content based on queries or search targets*. Scholarly reports have criticized the pedagogical approaches that focus on conveying fixed bodies of information and view students as passive recipients of knowledge [2]. If learners can determine what to construct or create, they are more likely to engage in learning [46]. Interactive video increases learner-content interactivity, thus potentially motivating students and improving learning effectiveness. Having video in small chunks that are well-indexed, and easily manipulated and incorporated into lessons is the first step to realizing its potential [29]. The LBA system used in our experiment used video that was logically segmented into small clips based on content. We have searched for but not found e-learning studies that have investigated the impact of interactive video.

3.2. The learning by asking (LBA) system

LBA is a multimedia-integrated e-learning system developed for our research. In order to increase the interactivity and have learners more engaged, the LBA system was designed and implemented to provide an interactive and personalized online learning environment enabling self-paced, anywhere, just-in-time knowledge acquisition.

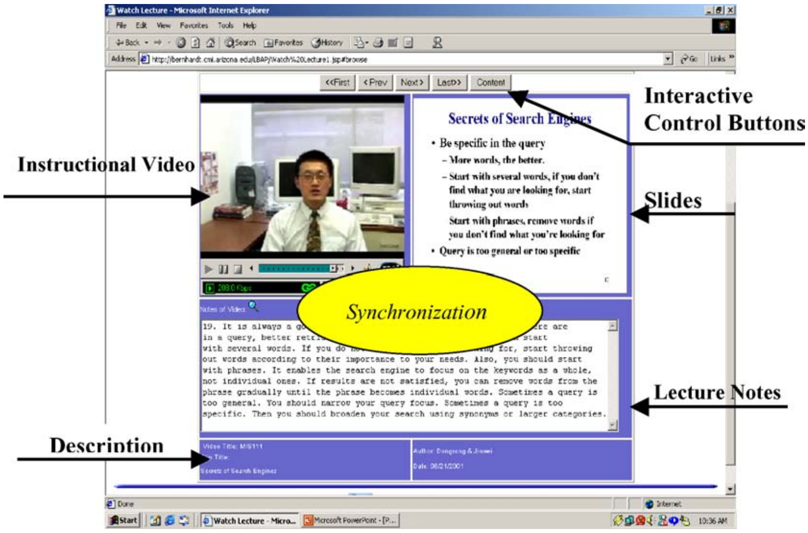

Fig. 1. The interactive e-classroom of the LBA system.

In this empirical study, students in e-learning groups used the interactive e-classroom sub-system embedded in the LBA system [55]. A student can watch a lecture with integrated instructional video, PowerPoint slides, and lecture notes (Fig. 1). S/he can see the video of the instructor, hear what he or she says, and read associated slides and lecture notes. These instructions are synchronized; thus, while an instructional video is playing, the LBA system can automatically present corresponding slides and lecture notes.

In order to provide interactive video, logic segmentation of the instructional video was performed. Each video clip explains an individual slide. If the learner does not interact, the whole lecture will automatically 'flow' from beginning to end. However, the learner can perform interactive operations at any time by pressing the control buttons at the top of the interface. For example, he or she can click the 'Next' button to skip the current video clip/slide/note or to press the 'Prev' button to go back. When he or she moves the mouse over the 'Content' button, a pull-down menu will display a hierarchical content index of this lecture. The subject can then directly jump to any particular video clip/slide/note by clicking a sub-topic (i.e., random access to video content). As a result, interactive video eliminates the linearity of traditional video.

In the LBA system, video is delivered from a video streaming server. It can be played as soon as a small portion is received by the client computer rather than after entire video is downloaded. A Web server, on which most of the information processing takes place, holds metadata of video and other instructional material. The metadata contains a variety of descriptive information about video clips, such as titles, speakers, keywords, and starting/ending time, etc.

4. Development of hypotheses

Our major research question was: *does interactive video enhance the learner's understanding and improve learning effectiveness*? The dependent variables were learning effectiveness, as measured by students' test scores, and perceived learner satisfaction, as measured by a survey instrument.

Interactivity is considered desirable and it is assumed that it can positively affect the effectiveness of education [21]. Increasing interactivity in an e-learning environment can reinforce concepts learnt and provide the ability for on-demand learning. However, there has not been empirical evidence to support these assumptions. There are three types of interaction: learner–instructor interaction, learner–learner interaction, and learner–content interaction [32]. There has been some research on the effect of learner–instructor and learner–learner interactions so we primarily focused on assessing the impact of learner–content interaction enhanced by interactive video.

Video is a powerful and expressive non-textual way to capture and present information [16]. It provides a multi-sensory learning environment that may improve learners' ability to retain information [49]. A number of studies examined whether the learning outcome is affected by the concurrent presentation of visual and verbal information in video but they generated mixed results. The video used in those studies was non-interactive. Some suggested that video can enhance learning outcomes due to vivid and fascinating presentations; e.g., Nugent [35] compared several components of video presentations and generally found better retention for stories presented via the combination of visual and auditory information than those presented via a single information source. On the other hand, other studies reported little impact of video on learning outcome [14,30]. However, those studies did not use online video. Although research suggests that instructional video increase learners' interest in subject matters and motivation of learning [53], the linearity of non-interactive video may severely reduce this potential effect.

Interactive video has not been widely used in e-learning until recently due to limitations of network bandwidth and multimedia technology. Interactive video can help entice learners to pay full attention to learning material through active interaction between learners and instructional video [1,52]. It provides effective means to view actual objects and realistic scenes. Particularly, interactive video in an e-learning environment not only provides visual and verbal cues but also enables learners to view any video portion as many times as they want. Therefore, we hypothesize that interactive video will improve learning outcome. The first hypothesis was:

H1a. Students who use the LBA e-learning environment with interactive instructional video will achieve better test scores than do students who use it without instructional video.

A number of studies have indicated that the overall learning outcome of e-learning with instructional video is either equal or superior to that of traditional classroom learning [7,19]. However, the impact of interactive video on learning effectiveness has been largely neglected. In comparison to traditional classroom learning, e-learning with interactive video offers several distinct advantages:

1. It allows online learners to watch in-class activities and listen to instructors repeatedly as needed, while, in a traditional classroom, students may not be able to ask instructors to repeat what they do not understand. Therefore, interactive video may provide better support to learners for understanding the learning material and enhances self-paced learning.
2. It enables random content access, which is expected to increase learner engagement [3,57], thus improving learning outcome and satisfaction.
3. It can increase the attention, involvement, and subsequent learning through individualized learning [17]. Traditional classroom learning is more instructor-centered, with controlled teaching pace and content. Students may easily lose attention when they do not follow the instructor.

Therefore, we propose that students in e-learning environments with interactive video can outperform those in traditional classrooms. So our second hypothesis was:

H1b. Given the same amount of instructional time, the test scores of students in the LBA e-learning environment with interactive instructional video will be better than those of students in the traditional face-to-face classroom.

In an e-learning environment, students and instructors are physically separated. Increased student engagement can improve learning outcome, such as promoting problem solving and critical thinking skills. Studies have suggested that learner engagement is higher with interactive than passive multimedia instruction: higher interactivity can lead to higher learner engagement [10] and better learning outcome [11,34].

Although some prior studies that used TV broadcast or video players reported learning outcomes comparable to those of a traditional classroom [18], an important pedagogical consideration, the ability to meet the learning needs of individual students, is severely limited by lack of interactivity. The limitation of linear video-playing processes can prohibit improvement of learning effectiveness.

Interactive video provides strong student motivation and engagement [44]. An interactive video-based learning system can be perceived as facilitating a constructivist learning environment [48]. Interactive video reduces limitations by providing control over the learning process and aid in the self-construction of competency of learning goals that result in greater performance [8]. Past research shows that learning achievement comparisons favor interactive over linear video [13,38]. Therefore, we hypothesize that an e-learning setting providing interactive video will help learners achieve better learning outcome. So our third hypothesis was:

H1c. Students who use the LBA e-learning environment that provides interactive video will achieve better test scores than do those in the LBA e-learning environment that presents non-interactive video.

Degrees of learner satisfaction have been widely used to evaluate the effectiveness of e-learning. E-learning environments differ substantially from traditional classroom environments. The adoption and success of this technology depends on learners' acceptance of this learning format.

It has been shown that students find video material attractive, leading to higher degrees of satisfaction [42]. Interestingly, most prior studies, regardless of the use of interactive [22] or non-interactive video [40], reported higher levels of learner satisfaction than learning without video. Hence, we proposed:

H2a. Students who use the LBA e-learning environment that provides interactive instructional video will report higher levels of satisfaction than will those using the LBA e-learning environment without instructional video.

H2b. Students in the LBA e-learning environment that provides non-interactive instructional video will report higher levels of satisfaction than will those using the LBA e-learning environment without instructional video.

Previous studies have reported mixed results about learners' satisfaction with e-learning. Some found that students were satisfied in general [4]. Students reported higher levels of subjective satisfaction with e-learning than with the traditional classroom learning [20]. They especially liked the flexibility and self-paced process. When an e-learning environment provides interactive video, the higher degree of process control can positively influence the effectiveness of knowledge transfer and lead to higher self-satisfaction [31].

In other studies, however, students were reported less satisfied [43]; e.g., Maki et al. [28] reported that students in the traditional classroom rated satisfaction higher than those in e-learning environments. A possible explanation is that students may experience frustration or anxiety during online learning [54]. They are accustomed to traditional classroom learning and when confronted with new technology-intensive learning environments, they tend to have negative attitudes that lessen but do not disappear over time. In light of those contradictory arguments, our sixth hypothesis was exploratory and non-directional:

H2c. Students who use the LBA e-learning environment that provides interactive instructional video will report different levels of learning satisfaction than do students in the traditional classroom.

Prior research linked higher levels of learner control and interactivity with increased student satisfaction [6]. Interactive e-learning environments that provide more exploration and interactivity capabilities can lead to higher degrees of learner satisfaction [23]. They give learners more control over both learning content and process to meet their individual learning needs. Therefore, we propose the final hypothesis:

H2d. The satisfaction levels reported by students who use the LBA e-learning environment that provides interactive instructional video will be higher than those reported by students in the LBA e-learning environment that presents non-interactive video.

5. Methodology

5.1. Research design

We conducted an experiment using the LBA system as the e-learning environment to test our hypotheses.

Table 1
Groups and treatments in the experiment

Groups	Learning environments	Group sizes
1	The LBA system that provided interactive instructional video	35
2	The LBA system that presented instructional video through VCR-type of video player (non-interactive video)	35
3	The LBA system that did not provide any instructional video	34
4	The traditional classroom environment where the lecture was offered in the traditional manner	34

Each subject participated in the study was randomly assigned to one of four groups, which was then randomly assigned to one of the four treatments (see Table 1).

Many studies in computer-aided learning have used a single session as the unit of analysis [41]. We argue that there is a trade-off between using a single session and using a sequence of multiple sessions. Although the longitudinal approach can mitigate a potential problem of the first approach, which the limited duration of the experiments may be partially responsible for the lack of convergent findings, it has its own problems: it is difficult to control and monitor learning activities of subjects. For example, few longitudinal studies have reported or compared the time spent by learners. If e-learning students spend much more time on mastering the material than traditional classroom students, then even if their test scores may not differ significantly, it does not mean that e-learning is as effective as classroom learning. In general, the experimental control difficulty may lead to problems while separating and interpreting effects of various e-learning environmental factors on learning effectiveness. Therefore, we chose a single lecture session in our study.

While the traditional classroom group took the lecture in a regular classroom, e-learning groups participated in a research laboratory at different time slots within the same day. The lab was equipped with 30 workstations with high-speed Internet connection and with all the necessary software already installed. Each subject had his/her own computer connected with a headphone set to be able to listen to the soundtrack of the video without disturbing others.

Although e-learning subjects took the online lecture using the LBA system, the system interface for each e-learning group was manipulated to be slightly different from each other. The interface of the LBA system for Group 1 (with interactive video) allowed subjects to interact with video through control buttons. By removing the control buttons, it became the interface for Group 2 (with non-interactive video). Subjects in this group could still use the ‘stop’ and ‘pause’ buttons provided by the Real Player, as well as fast-forward or rewind function by dragging the scroll bar. However, the latter was not of much help for efficiently locating a specific segment of the video due to the loss of audio track and few scene changes in the instructional video. The LBA system used by Group 3 presented only PowerPoint slides and lecture notes but without video. Group 4 (traditional classroom group) took the lecture in a traditional format without using the system.

Because the focus of this study was individual learning, rather than collaborative learning, and because we wanted to control possible confounding factors, learners were not allowed to use emails or an online discussion forum embedded in the LBA system to communicate during the experiment.

5.2. Subjects

Like most e-learning studies, undergraduate students were chosen as subjects [27]. We recruited 138 undergraduate students from a large university located in the south-west of the United States. Students were clearly informed that this experimental study was provided as a bonus assignment of the course, and they could participate in it on a voluntary basis. In order to encourage serious participation, the instructor agreed to offer up to 5 extra credits (5% with respect to their total course grades) to participants based on their individual performance. Participants were recruited from multiple sessions of an introductory course in MIS. Subjects came from seven departments across the campus, such as MIS, electrical engineering, communications, and arts. They were either freshmen (92%) or sophomores (8%). Fifty nine percent of the subjects were male.

Because the objective of this study was mainly to investigate the effect of interactive video on learning effectiveness, learner characteristics were not considered as independent variables; the study depended on random distribution of participants across treatments to balance out individual differences. Participants completed a preliminary survey two weeks before the experiment to provide their demographic information such as age, GPA, computer experience, and prior experience of e-learning. A series of analysis did not find significant difference among four groups on those dimensions. The average age of participants was less than 21 (90%). None of participants had any previous experience with e-learning. Therefore, we could assume homogeneity of pre-experiment skills, e-learning experience, and learner characteristics among groups. Such subject homogeneity avoided complicated effects potentially caused by disparate characteristics of heterogeneous learners.

5.3. The lecture content

The lecture topic in the experiment was Internet search engines, a part of the Internet technology section in the course syllabus. Therefore, we avoided the problem of asking subjects to learn a subject matter that was outside their course. The lecture introduced basic concepts of information retrieval, different types of search engines, and explained how search engines work.

The instructor in the traditional classroom group also prepared the online instructions in advance, including a videotaped lecture, slides, and lecture notes, which were processed and stored in an online knowledge repository for the e-learning groups. When giving the lecture to the traditional classroom group, the instructor taught the same content as he did in the instructional video.

5.4. The procedure

Subjects in all e-learning groups went through the same procedure:

(1) *Introduction*: At the start of each session, the objective and procedure of the experiment were clearly described.
(2) *Pre-test*: Subjects took a written pre-lecture test, which included a number of true–false and multiple-choice questions. The questions were about basic concepts that the lecture would introduce. The purpose of this test was to examine how much a subject already knew about the topic. No significant differences in pre-test scores among the four treatment groups were discovered.
(3) Learners who were to use the LBA system received about 5 min of training during which they saw a brief live demonstration about how to watch an online lecture using the LBA system. They were given the same amount of time to familiarize themselves with the system. The system had been designed and implemented with an easy-to-use interface and no participant reported any difficulty in using it.
(4) *Online lecture session*: After all participants understood how the system worked, they were given 50 min to watch the online lecture. The instructional video, which was prepared in advance, lasted about 29 min. This gave participants extra time to review the learning material. There were 20 slides in this lecture.
(5) *Post-test and questionnaire*: At the end of each session, participants were given another written exam, consisting of objective questions (with standard answers) about the lecture content, such as calculating TF-IDF values of terms in a document and describing three basic approaches to searching the Web. The question types in the post-test were similar to those in the pre-test, but questions were more specific and difficult. After the test, each participant was required to fill out a questionnaire to assess his or her perceived satisfaction and to give feedback on the system and their learning experience.

Both pre- and post-tests were closed book, closed notes. During e-learning sessions, participants could take notes but they were not allowed to discuss issues with each other, thus eliminating the influence of peer interaction on individual performance. The potential test scores ranged from 0 to 50. The duration of the lecture session and tests were the same for all e-learning groups.

The traditional classroom group was given the same lecture. The content of the real-time lecture was controlled to ensure its consistency with that of the online lecture. Participants in the classroom group went through the same procedure as that of e-learning groups, except that the steps 3 and 4 were replaced by a 50 min regular in-class lecture and review session. They were allowed to ask questions about the lecture content as usual.

Each participant was given a hard copy of the PowerPoint slides at the beginning of each session. The learning outcome was measured by the difference between individual post- and pre-test scores (represented as 'post-gain'). The pre- and post-tests were graded by two graduate teaching assistants who knew nothing about the experimental treatments. In the questionnaire, participants were asked to rate their satisfaction with learning effectiveness using a 7-point Likert scale, ranging from extremely dissatisfied (1) to extremely satisfied (7), as well as to provide open comments on the system.

6. Analyses and results

Scores of both pre- and post-tests were examined for ceiling and floor effects; none was found. During the experiment, the LBA system also automatically captured every learner-content interactive operation (control-button click by each subject) in the e-learning group with interactive video. The average number of random content access was 7.3 per participant.

Table 2 shows the means and standard deviations of learning outcomes of students in different experimental groups. We performed a one-way, between-subjects analysis of variance (ANOVA), with differences between pre- and post-test scores (post-gain) as the dependent variable and experimental treatment as the independent variable. The results indicate that there is significant difference among the group means ($F(3, 134) = 9.916$, $P = 0.00$).

Results of a post-hoc Tukey test are shown in Table 3; they show that the post-gain of the e-learning group with interactive video that allowed random content access (group 1) was significantly higher than that of the other three groups. Therefore, hypotheses H1a, H1b, and H1c received support.

Table 2
Descriptive statistics of learning outcome in different treatments (post-gain)

Groups	Means	Standard deviations
E-learning group with interactive video (1)	34.1	8.87
E-learning group with linear video (2)	27.7	8.85
E-learning group without any video (3)	26.7	10.02
Traditional classroom group (4)	23.7	8.79

Table 3
Mean differences (*P*-values) between groups on learning outcome (post-gain)

Groups	2	3	4
1	6.49 (0.005)**	7.41 (0.001)**	10.47 (0.00)**
2		0.92 (0.967)	3.98 (0.184)
3			3.06 (0.417)

** The mean difference is significant at the 0.01 level.

In addition, there was no statistically significant difference in the post-gain between the e-learning group with non-interactive video (group 2) and the e-learning group without any video (group 3). This implies that the interactive video with random content access may help students enhance understanding of the material and achieve better performance, while non-interactive video may have little effect.

Table 4 lists the means and standard deviations of satisfaction levels of all groups. The results of a one-way ANOVA analysis reveal significant difference

Table 4
Descriptive statistics of learner satisfaction

Groups	Means	Standard deviations	*N*
E-learning group with interactive video (1)	6.46	0.56	35
E-learning group with non-interactive video (2)	5.94	0.84	35
E-learning group without instructional video (3)	5.74	0.75	34
Traditional classroom group (4)	5.03	0.67	34

Table 5
Mean differences (*P*-values) between groups on satisfaction

Groups	2	3	4
1	0.51 (0.014)*	0.72 (0.00)**	1.43 (0.00)**
2		0.21 (0.621)	0.91 (0.00)**
3			0.71 (0.00)**

* The mean difference is significant at the 0.05 level.
** The mean difference is significant at the 0.01 level.

among the group means by satisfaction levels ($F(3, 134) = 23.696$, $P = 0.00$). Table 5 presents the results of a post-hoc Tukey test.

The post-hoc Tukey test revealed that students in the e-learning group with interactive video that allowed random content access (group 1) reported significantly higher levels of satisfaction than any of the other three groups. Therefore, hypotheses H2a, H2c, and H2d are supported. Students in all three e-learning groups had significantly higher levels of satisfaction than those in the traditional classroom group (group 4). However, students in the e-learning group with non-interactive video (group 2) had equivalent levels of satisfaction to those in the e-learning group without any video (group 3) ($P = 0.62$), so H2b is not supported.

7. Discussion

The tests supported our hypotheses on the positive effects of interactive video on both learning outcome and learner satisfaction in e-learning. Our findings provide some insights on how to present instructional video in an e-learning environment in order to achieve higher effectiveness.

Students in the LBA group with non-interactive video achieved equivalent test scores and levels of satisfaction to those in the e-learning group without video. This implies that simply integrating instructional video into e-learning environments may not be sufficient to improve the e-learning effectiveness. Daily has argued: ''One of multimedia's strongest contributions to learning is increased visualization'' [12]. Our findings confirm those of previous research that the use of linear instructional video in education does not always have positive effect. Video may lead to better learning outcome, but results are contingent upon the way it is used.

Many participants in the group 1 reported in their questionnaires that they liked the capability of interacting with multimedia instructions the most. In the meantime, a number of students in the non-interactive group commented on the difficulty of efficiently skipping or browsing for a specific portion of the video. As a result, some were reluctant to re-watch the video when they failed to understand the content. This study provides some empirical evidence to the importance of interactivity of video instructions in e-learning.

This study has several limitations. First, the scope of the study was limited: the success with e-learning may vary by content and some topics or courses may be better-suited to e-learning than others. Second, this experiment examined a single class session. Further, longitudinal studies can examine whether the identified effects can be obtained throughout an entire course. Third, we used undergraduate students in an American university, who were appropriate for this e-learning research. Results should be generalizable across populations. However, currently, we cannot offer empirical support that they do.

Although the findings in this study are encouraging, we are not in a position to claim that interactive video-based e-learning is always superior to traditional classroom learning. The value of e-learning may depend on many factors, including learners, instructors, technology (e.g., e-learning environments themselves), production values, and content. However, this study does show that, under certain circumstances, interactive e-learning can produce better results than other methods.

8. Conclusion

Researchers have reported mixed results with deploying multimedia e-learning systems. Our study demonstrated that simply incorporating video into e-learning environments may not always be sufficient to improve learning. Interactive video that provides individual control over random access to content may lead to better learning outcomes and higher learner satisfaction. The study offered an explanation for inconsistent findings reported in previous studies. It suggests that interactivity can be a valuable means to improve learning effectiveness in e-learning environments.

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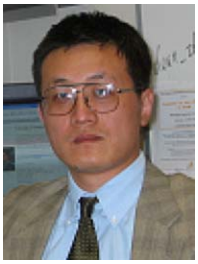

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