Video in distance education: ITFS vs. web-streaming: Evaluation of student attitudes

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Abstract

The use of video in distance education courses has a long tradition, with many colleges and universities having been delivering distance education courses with video since the 80's using the Instructional Television Fixed Service (ITFS) and cable television. With the emergence of the Internet and the increased access bandwidths from private homes to the Internet, the delivery of distance education video via web-streaming has become more widespread and appears poised to replace the delivery of distance education video through ITFS/cable TV. At this juncture in the history of distance education video delivery it is important to take the student attitudes toward these different forms of educational video delivery into consideration. This naturalistic evaluation study examined and compared the attitudes of a total of close to 360 students who had taken distance education classes with video, whereby approximately 180 of the students had participated in classes with ITFS/cable TV video delivery and approximately 180 students had taken classes with web-streaming video delivery. The overall student satisfaction was found to be approximately the same with either form of distance education video delivery.

However, there were statistically significant differences in the student attitudes towards specific aspects of the distance education video, such as perceived video quality, technical problems, and preferences for control over the instructional flow.
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1. Introduction

Distance education (DE) has a long tradition and is often delivered in the form of video (Jesshope & Liu, 2001; Klein, 1998; Latchman, Salzmann, Gillet, & Bouzekri, 1999; Moore & Kearsley, 1996; Pullen, 2001; Schamber, 1988; Simonson, Smaldino, Albright, & Zvacek, 2003; Tobagi, 1995). The three main profiles of distance education with video that have emerged are (Hart-Davidson & Grice, 2001; Simonson et al., 2003): (i) interactive two-way video and audio, which corresponds essentially to a video conference (Hu et al., 2002; Tesone, Kelsey, Gibson, & Blackwell, 2002), (ii) one-way live video and two-way audio (Fong & Hui, 2001), and (iii) one-way delayed audio and video (Bargeron, Gupta, Grudin, & Sanocki, 1999; Haga, 2002). The interactive two-way video and audio distance education has the advantage of most closely resembling the presence in the classroom but requires high-speed networks (Klein, 1998) and also requires that all learners participate at the same time (synchronously). Due to the scarcity of bandwidth, particularly in the last mile to the students' homes, the one-way video and two-way audio profile of distance education has been widely employed. Many colleges and universities have been offering distance education courses in this profile since the 80's. In these courses, the video feed (including the instructor audio) is delivered using a combination of satellite and terrestrial microwave links in the context of the Instructional Television Fixed Service (ITFS) system (Gossman, 2001), or is delivered through local cable channels or public broadcasting TV channels. The distance students have the opportunity to place a phone call to the instructor in the classroom studio to ask questions and interact with the instructor. Of course, the distant students can only call in to the classroom studio if they are attending the class synchronously. In order to view the class video at a different time (asynchronously), the distance students have to videotape the class video for later viewing. With the taping, this form of distance education falls essentially into the one-way delayed video and audio profile.

Up until very recently many colleges and universities extensively employed the distance education video delivery via the ITFS and cable/public TV channels. For instance, the National Technological University (NTU) delivered most of its distance learning courses using the ITFS system until approximately the year 2003. Around the year 2003, the NTU and many colleges and universities began to phase out the video delivery via ITFS/cable TV and to replace it by the delivery of the distance education video via web-streaming (Shephard, 2003). The web-streaming distance education offered today falls mainly into the one-way video and audio profile. The class video (along with the instructor audio) is typically recorded in a classroom studio–often filled with on-campus students–and posted on the class web site a few hours after the recording. The distance learners can then view the class video by streaming it from the class web site and interact with the instructor asynchronously, e.g., via e-mail or web-based discussion boards.

As many schools and colleges are considering or making the transition from the distance education video delivery via the ITFS/cable TV to the web-streaming delivery, an important issue is the attitude of the distance students toward these forms of distance education video delivery. Key questions include: "How do the students perceive the technical quality of the delivered video?", "How do the students perceive the ease of navigation and control of the distance education video?", and "How do the students perceive the overall effectiveness of the distance education class?". To address these questions, the authors have conducted a large-scale survey-based naturalistic evaluation study of close to 360 students who have taken distance education courses at Arizona State University (ASU), whereby approximately 180 of the surveyed students had participated in classes with ITFS/cable TV video delivery and approximately 180 students had taken classes with the web-streaming video delivery.

1.1. Related work

The comparative evaluation of traditional in-classroom instruction with distance education has received considerable interest and it has been demonstrated that distance education can be as effective as traditional in-classroom instruction (Lilja, 2001; Moore & Kearsley, 1996; Simonson et al., 2003). The use of video in distance education courses has been examined for many different content areas, including law (Perritt, 2000), nursing (DeBourg, 2003), dentistry (Johnson, Lohman, Sharp, & Krenz, 2000; Reynolds & Mason, 2002), business administration (Brindle & Levesque, 2000), human–computer interaction (Hart-Davidson & Grice, 2001), gerontology (Burrow & Glass, 2001), social work (Foster & Washington, 2000), engineering (Pullen, 2001), as well as corporate training (Prough, Rao, Samota, & Moore, 1997). The evaluation of student attitudes toward distance education with video has been examined (see for instance, Hilgenberg & Tolone, 2000), and it has been found that students have generally a positive attitude toward the distance learning technology and their course experiences. The development and refinement of prototype systems and teaching strategies for distance education with video has received significant attention (see for instance, Krull, 1998; Latchman & Gillet, 2000; McMullin & Owen, 2002; Ostendorf, 1997; Unruh, 2000). In addition, techniques for evaluating distance education have been studied extensively (see for instance, Chang, 2002; McGorry, 2003; Novak, 2002; Rovai, 2003). The study by Lee and Forde (2002) examined the perceptions of students toward the design of distance learning classrooms. Recently, the embedding of streaming video segments in distance learning modules has received interest. For instance, the study by Green et al. (2003) compared the student access patterns and attitudes toward three learning sessions which contained streaming video and found that the access and attitudes were largely uniform across the different sessions. The study by Cofield (2002) compared the effectiveness and attitudes toward a distance learning module consisting of text and still images without and with embedded streaming video clips and found that the clips helped to hold the student attention and convey a feeling of instructor presence. This present evaluation study is complementary to the reviewed literature in that the authors examine the attitudes of the students toward different forms of distance education video delivery.

The impact of different forms of video delivery in distance education has received relatively little interest to date. Cofield (2003) compared streaming video and videotapes with respect to the way they convey affective meaning. The impact of the studio context, i.e., the instructor teaching to a camera only or to a live audience in the studio classroom, was examined in the study by Fritze and Nordkvelle (2003). The impact of the number of windows in web-streaming distance education video was studied by Reynolds and Mason (2002); in particular, one window video showing either the instructor or presentation slides/instructor writing pad was compared with two-window distance education video, where one window displayed the "talking head" of the instructor and the second window displayed the presentation slides/writing pad, and with a three-window distance education interface, where a live chat window was added. Annetta and Matus (2004) compared the live distance education video delivery using a system similar to ITFS with the delayed delivery over the same system and found no significant differences between these two types of delivery. The evaluation conducted by the authors is complementary to the existing comparative studies in that the authors compare the student attitudes toward DE video delivery via the ITFS/cable TV with the student attitudes toward DE video delivery via web-streaming.

2. Distance education video delivery forms: ITFS/cable TV and web-streaming

This section provides an overview of the two forms of video delivery for distance education compared in this study, namely (i) the delivery via the Instructional Television Fixed Service/Cable TV system, and (ii) web-streaming. In addition to a general overview of these delivery modes, this section also briefly describes the specific forms of the delivery modes employed at Arizona State University (ASU), where this evaluation study was conducted. In general, at ASU, the classes offered in the video distance education forms are taught live to on-campus students in a studio classroom and at the same time are captured for distance education delivery.

2.1. ITFS video delivery

The ITFS system provides a band of television channels that are transmitted over wireless microwave links and have relatively short range (20–35 miles). These TV channels can be licensed by the Federal Communications Commission (FCC) to local credit granting educational institutions. At ASU, the ITFS system was used to deliver distance education video from ASU's Tempe campus to remote classrooms in several corporations in the Phoenix metropolitan area and to ASU's other campuses up to the fall 2002/ spring 2003 semesters. Over the fall 2002/spring 2003 semesters, the ITFS delivery to remote classrooms in corporations was phased out and replaced by web-streaming, as detailed below. At present, the ITFS system continues to be used to deliver distance education video from ASU's Tempe campus to the other ASU campuses. In collaboration with the local cable company, Cox Digital Cable, ASU is also delivering distance education video over cable channel 116. In addition, ASU delivers distance education video over the public television system in collaboration with the local PBS station, KAET Channel 8.

The delivery of the distance education video over the ITFS system and over cable/public TV has several common key characteristics. First, the video displays typically one window, which shows either the instructor, or the blackboard, or the instructor's writing pad. (Generally, the video technology allows also for a two-window presentation where the entire screen displays the writing pad and a small window of the instructor's "talking head" is superimposed in the upper right corner of the screen.) Second, the ITFS/cable TV delivery falls generally into the one-way video and two-way audio distance education delivery profile, i.e., the video (including the audio from the instructor and the students in the studio classroom) is delivered from the classroom studio to the remote ITFS site/student TV. (At ASU, in some cases which are uncommon, the cable delivery of the video is delayed, in which case the students cannot call into the classroom studio and the delivery mode is essentially a one-way video and audio delivery mode.) If students cannot watch the classes at the time they take place and are being delivered over the ITFS/cable TV system, they can record the class on videotape for later viewing. The videotapes can also be used by the students to review the class at a later time, e.g., when preparing for an exam.

2.2. Web-streaming video delivery

The web-streaming delivery of distance education video was phased in at ASU over the fall 2002 and spring 2003 semesters. At present all engineering distance education courses are delivered with web-streaming video at ASU. In addition, some of the distance education courses from other schools and colleges are delivered with web-streaming video.

There are a variety of systems for the video streaming of lectures (McCrohon, Lo, Dang, & Johnston, 2001; Rowe, Harley, Pletcher, & Lawrence, 2001). The current web-streaming distance education video at ASU is delivered with the Mediasite Live tool from Sonic Foundry (Sonic Foundry, 2004). The web-streaming presents two windows, namely a video window and a slide window. The video window, which has the dimensions of 240×180 pixels, shows a video of the instructor or the instructor writing pad/blackboard. This video is encoded with the WindowsMedia Video 9 at a bit rate of approximately 100 kbps and a frame rate of 15 frames/s. The audio of the instructor is encoded with WindowsMedia Audio 9 Voice at 12 kbps. The slide window, which has the dimensions of 500×375 pixels, provides snapshots of the instructor writing pad/blackboard. Each snapshot is encoded as a JPEG image with a size ranging typically between 20 and 30 KB. A new snapshot is taken for each new slide that the instructor displays to the class, or in case the instructor writes on the writing pad/blackboard, a new snapshot is taken periodically typically every 30 to 60 s so as to keep track of the significant changes on the writing pad/blackboard. With web-streaming, the delivery mode is one-way video and audio. The class video is posted on the class web site a few hours after the on-campus class has taken place. Consequently, the distance students receive the video asynchronously from the on-campus class time. The web-streaming delivery allows the students to view a slide list which displays thumbnails of typically ten slides in the slide window at a time and allows the students to make jumps in the video window to the beginning of the video sequence corresponding to a selected slide.

3. Survey-based evaluation study methodology

This evaluation study examined and compared the attitudes of students enrolled in distance education classes with a video component that was delivered (i) via the Instructional Television Fixed Service (ITFS)/cable TV system, and (ii) via web-streaming.

A 30-item web-based survey was designed to solicit the feedback of the distance learners at ASU. The survey first asked the students to indicate which form of video delivery they are evaluating, whereby the options were Cable TV/ITFS and Web-Streaming. The students then were asked for basic demographic information. In the following five parts, the survey asked for the students' evaluation of and attitudes toward

- the technical aspects of the video delivery,
- the delivery mode,
- the navigation and control,
- the interactivity, and
- the overall perceived effectiveness

of the class video. Each survey item consisted of a statement about an aspect of video in distance education accompanied by a 5-point Likert-type rating scale on which the respondents indicated their level of agreement with the statement from strongly agree to strongly disagree. In addition, the students were asked for open-ended comments on the aspects they liked the best/the least about the video distance education, ways to improve the use of video in distance education, and any other comments or suggestions. Following Aiken (1997) the construct validity of the survey was assessed with the judgment of subject matter experts on distance learning programs with video delivery in conjunction with a pilot

with a sample of the target audience. Also, the internal consistency of the survey was analyzed. This analysis resulted in a Cronbach's alpha of 0.83 which indicates a high level of internal consistency.

Solicitations to complete the survey, which was to be completed anonymously through a web interface, were e-mailed in April 2004 by the Center for Professional Development in ASU's Fulton School of Engineering and ASU's Distance Learning and Technology program office. These e-mail solicitations reached a random sample of distance learners who were currently enrolled in a distance education course with a video component as well as the alumni from such classes from the past several years. This ensured that students who had participated in classes with web-streaming video delivery as well as students who had taken classes with ITFS/Cable TV video delivery were reached. A total of 356 fully completed surveys were returned.

This study has the general limitations that are common for survey studies, such as the completed surveys being self-reports (see for instance, Gravetter & Forzano, 2003). Another limitation is that the evaluated web-streaming system for distance video delivery is relatively novel and not all students might have been fully aware of this delivery option and all the ways in which the web-streaming interface can be operated. This unfamiliarity with all the interface features might have affected the learning process and the student attitudes. A unique characteristic of this study is that it was conducted at Arizona State University, a large public university located in a metropolitan area in the Southwest of the U.S. with a diverse student body. This evaluation study was naturalistic in nature, whereby the respondents were part of already existing groups and thus were not randomly assigned to the two compared forms of DE video delivery. Furthermore, a large representative sample of DE video courses was evaluated, therefore broadening the instructor base and the corresponding subject areas.

4. Results and discussion

This section presents and discusses the main results of the present evaluation study. This section is organized according to the five main parts of the survey and presents also an evaluation of the received open-ended responses. Throughout the 5-point Likert-type survey statements were scored by assigning a score of 4 to the rating of "strongly agree", 3 to "agree", 2 to "neither agree nor disagree", 1 to "disagree", and 0 to the rating of "strongly disagree". The results tables generally report the mean scores (M) and standard deviations (S.D.) of the responses across all 356 surveys, as well as for the two compared forms of video delivery. The tables also present the one-way analysis of variance (ANOVA) results, in particular, the F-ratio (F) with the corresponding degrees of freedom, the mean-square-error (MSE), and the statistical significance level p, for the comparison of the scores for the two compared forms (ITFS/ cable TV and web-streaming) of DE video delivery. This ANOVA procedure is equivalent to an independent sample t test. Only those surveys which have been fully completed, i.e., on which all 30 survey statements have received a response, were considered in the analysis. A total of 356 fully completed surveys were received, of which 177 evaluated the DE video delivery via ITFS/cable TV and 179 evaluated the DE video delivery via web-streaming.

4.1. Demographics of survey respondents

This section summarizes the responses to the demographic questions. Approximately two-thirds of the ITFS respondents were female (67%), whereas for the web-streaming approximately half of the

respondents were male (52%) and half were female (48%). Approximately two thirds of the total respondents were full-time students (68%). The authors learned from the responses to the open-ended questions that many of these full-time students take a mix of traditional on-campus classes and distance education classes. The ratio of full-time students was significantly higher for the ITFS video delivery (76% full-time to 24% part-time) compared to the web-streaming video delivery (60% full-time to 40% part-time), $F(1354)=9.87$, MSE=0.21, $p<0.01$. The distribution of the distance of the ITFS respondents from the campus offering the distance education was as follows: 26% resided less than 5 miles from the campus, 24% between 5 and 10 miles, 27% between 10 and 20 miles, 18% between 20 and 50 miles, 2% between 50 and 100 miles, and 3% over 100 miles. For the web-streaming respondents, the distribution shows that 22% resided less than 5 miles from the campus, 14% between 5 and 10 miles, 21% between 10 and 20 miles, 20% between 20 and 50 miles, 3% between 50 and 100 miles, and 20% over 100 miles. These distributions indicate that the web-streaming respondents resided further away from the campus offering the distance education class and were wider-spread. One possible explanation for the differences in the student status and distance to the campus among the respondents for the two compared forms of DE video delivery may be that the web-streaming is preferred by working adults. Especially for professionals whose jobs require travel, the web-streaming has the distinct advantage of being accessible with a laptop from any place with Internet connectivity, whereas the ITFS/cable TV delivery requires presence in the ITFS remote classroom or access to the VCR that records the classes. In addition, the web-streaming allows working professionals to access the class video through the Internet connection at the workplace and to catch up on classes during work breaks.

4.2. Technical aspects of video delivery

Table 1 presents the results for the four survey items relating to the technical aspects of the DE video delivery. Statistically significant differences between the responses for the two compared forms of DE video delivery were observed for the item relating to the video quality, $F(1354)=11.62$, MSE=1.05, $p<0.01$, and the item relating to the technical difficulties, $F(1354)=7.46$, MSE=1.26, $p=0.01$. In particular, the ITFS respondents perceived the video quality as significantly better (M=3.09, S.D.=0.95) than their counterparts in the web-streaming delivery format (M=2.72, S.D.=1.09). At the same time, the respondents who watched the DE video via the web-streaming reported significantly more technical problems (M=1.70, S.D.=1.18) than students watching the class

Table 1
Technical aspects of video delivery

Survey statement	Overall (N=356)		ITFS (N=177)		Web-streaming (N=179)		ANOVA		
	M	S.D.	M	S.D.	M	S.D.	F(1354)	MSE	p
The video quality was good.	2.90	1.04	3.09	0.95	2.72	1.09	11.62	1.05	0.00*
The audio quality was good.	2.97	0.95	2.96	0.93	2.99	0.96	0.08	0.90	0.78
It was easy to access the class video (VCR, web connection).	3.10	1.01	3.08	1.06	3.12	0.98	0.13	1.03	0.72
I encountered technical problems when watching the class video.	1.54	1.13	1.37	1.06	1.70	1.18	7.46	1.26	0.01*

* Denotes statistically significant difference between ITFS/cable TV and web-streaming.

video in the ITFS format (M=1.37, S.D.=1.06). The respondents for both forms of DE video delivery agreed approximately equally strongly with the positive statements about the audio quality and ease of access to the class video.

Overall, these results indicate that the quality of the video in the web-streaming system that the respondents had experienced falls short of the video quality perceived for the ITFS/cable TV delivery. The data also suggest that the web-streaming delivery is more prone to technical difficulties. The analysis of the open-ended comments related to these two issues revealed that the web-streaming students perceived the video as low in resolution, which tends to make it difficult to read the instructor's writing on the writing pad or blackboard. The web-streaming students noted that the experienced occasional outages of the video web-streaming service (e.g., due to server problems/ maintenance, outages in the Internet service) to some extend interfered with their "anytime-anywhere" study habits. Thus, there appears to be a need for the video web-streaming technology to mature more before the video quality that it provides is considered on par with the video delivered through the ITFS/cable TV system for the purpose of distance education. Interestingly, the technology for the audio component in the web-streaming appears to already have matured to a point where it is perceived as equivalent to the audio delivered over the ITFS/cable TV system for the purpose of distance education.

It is interesting to note that respondents for both forms of video delivery had approximately equally positive attitudes towards the ease of access to the class video, despite the advantage of the web-streaming being accessible from any place with an Internet connection versus the ITFS/cable TV delivery requiring presence in the remote classroom or access to the VCR recording of the class video. One explanation of this result is that the majority of respondents either were only familiar with the one form of video delivery that they were evaluating, or those who were attending the ITFS classes did not perceive it as restricting them in terms of location.

4.3. Delivery modes of distance education video

Table 2 reports the results for the five survey items relating to the delivery mode of the video. Statistically significant differences were observed between the two forms of video delivery for all

Table 2
Delivery modes of distance education videos

Survey statement	Overall (N=356)		ITFS (N=177)		Web-streaming (N=179)		ANOVA		
	M	S.D.	M	S.D.	M	S.D.	$F_{(1354)}$	MSE	p
I prefer the video delivery on videotape.	1.74	1.25	2.07	1.25	1.42	1.18	25.12	1.47	0.00*
I prefer the video delivery over the web.	2.85	1.18	2.42	1.22	3.28	0.97	53.73	1.21	0.00*
I prefer to watch the video in real time while the class is being taught on campus.	1.82	1.21	2.08	1.16	1.55	1.21	17.96	1.40	0.00*
I prefer to watch the video independently of the on-campus class time.	3.02	1.07	2.90	1.10	3.14	1.03	4.39	1.13	0.04*
I liked the anytime/anywhere convenience of taking a video distance education course.	3.57	0.78	3.53	0.79	3.61	0.76	0.90	0.60	0.34

 * Denotes statistically significant difference between ITFS/cable TV and web-streaming.

items, except the item relating to the anytime/anywhere convenience of a video distance education course, with which respondents for both delivery forms strongly agreed (M=3.57, S.D.=0.78). While the ITFS respondents were indifferent towards the video delivery with videotape (M=2.07, S.D.=1.25), the web-streaming respondents disagreed with videotape being the preferred form of video delivery (M=1.42, S.D.=1.18). These preference differences were statistically significant, $F(1354)=25.12$, MSE=1.47, $p<0.01$. The video delivery via web-streaming was clearly the preferred form of video delivery for the web-streaming students (M=3.28, S.D.=0.97), whereas the ITFS/cable TV students were between being indifferent and agreeing with this survey item (M=2.42, S.D.=1.22). These preference differences were statistically significant, $F(1354)=53.73$, MSE=1.21, $p<0.01$. The results for these two survey items overall indicate that the web-streaming students are clearly in favor of the web-streaming delivery while the ITFS/cable TV students appear to welcome the option of web-streaming (as indicated in their higher preference rating for the web delivery compared to their preference rating for video tape delivery). On the other hand, web-streaming students appear not to be open to the delivery via videotape.

The ITFS students were indifferent (M=2.08, S.D.=1.16) towards watching the video in real-time, simultaneously with the class offering on campus, whereas the web-streaming students were between being indifferent and disagreeing (M=1.55, S.D.=1.21) with this mode of watching the class video. The ITFS respondents were also largely in agreement (M=2.90, S.D.=1.10) with watching the class video asynchronously from the on-campus class time. The preference for watching the class video asynchronously was stronger among the respondents for the web-streaming (M= 3.14, S.D.=1.03), and this difference was statistically significant, $F(1354)= 4.39$, MSE=1.13, $p<0.05$. Overall, there appears to be a pronounced tendency for the web-streaming students to prefer the independence of watching the class video at their own time, whereas the ITFS students appeared indifferent about conforming with the on-campus class time and were less enthusiastic about the freedom of watching the class video at their own time. One effect that may have an impact on these attitudes is that the ITFS respondents, who were on average more predominantly full-time students, acknowledged that it is beneficial to work on the class on a regular schedule that is imposed by the university. On the other hand, it appears likely that the web-streaming respondents, who were on average more predominantly part-time students, felt that they have matured the discipline and self-regulating skills enabling them to keep up with class work and to succeed in the class by pacing their own work.

As already noted above, the respondents for both forms of video delivery strongly preferred the anytime/anywhere convenience of distance education, whereby the web-streaming respondents were slightly stronger in their preference; however, this difference was not statistically significant.

4.4. Navigation and control of distance video

Table 3 reports the results for the six survey items relating to the navigation and control of the distance education video. The results indicate that respondents for both forms of video delivery preferred to have visual-based organizers. The preference of the web-streaming respondents was somewhat stronger (M=3.13, S.D.=0.78) compared to the preferences of the ITFS respondents (M=2.98, S.D.=0.74). There was a statistically significant difference, $F(1354)=22.43$, MSE=0.53, $p<0.01$, in the preference for having control over the instructional flow of the video with the web-streaming respondents having stronger preferences (M=3.63, S.D.=0.67) compared to the ITFS respondents (M=3.26, S.D.=0.78).

Table 3
Student preferences towards navigation and control

Survey statement	Overall (N=356)		ITFS (N=177)		Web-streaming (N=179)		ANOVA		
	M	S.D.	M	S.D.	M	S.D.	F(1354)	MSE	p
Having visual-based organizers, e.g., table of content was/would be helpful.	3.06	0.77	2.98	0.74	3.13	0.78	3.49	0.58	0.06
I liked having control over the instructional flow (e.g., go back, forward the video).	3.44	0.75	3.26	0.78	3.63	0.67	22.43	0.53	0.00*
It was convenient to fast forward/rewind the video to a specific part of class.	3.20	0.96	3.12	0.93	3.27	0.99	2.00	0.92	0.16
Structure of class was clear; I always knew where I was in the class video.	2.86	1.08	2.79	1.08	2.93	1.07	1.67	1.16	0.20
I prefer to have one presentation window for the video (switching between instructor and content slides).	1.90	1.08	2.13	0.91	1.68	1.19	15.96	1.12	0.00*
I prefer to have two presentation windows for the video (one for instructor, the other for content slides).	2.71	0.97	2.49	0.89	2.93	1.00	19.42	0.89	0.00*

 * Denotes statistically significant difference between ITFS/cable TV and web-streaming.

Overall, the results for these two survey items indicate that both ITFS and web-streaming students prefer clear organization and control over the flow of the class video, with the web-streaming students having stronger preferences.

The results furthermore indicate that both the ITFS respondents (M=3.12, S.D.=0.93) and the web-streaming respondents (M=3.27, S.D.=0.99) generally found it convenient to navigate the class video. Also, both ITFS respondents (M=2.79, S.D.=1.08) and web-streaming respondents (M=2.93, S.D.=1.07) generally clearly understood the structure of the class and were aware of their position in the class video. The web-streaming respondents found the video navigation somewhat more convenient and were somewhat clearer on the class structure. These differences, however, were not statistically significant. This is an interesting result since the slide window in the web-streaming delivery offers the option of viewing a thumbnail overview of the slides of the class and to access the video via the thumbnails. It would appear that this form of accessing the class video makes the navigation of the class video much more convenient compared to rewinding/fast forwarding a videotape. One explanation for the thumbnail navigation option in web-streaming not resulting in statistically significantly more favorable student attitudes is that the students were possibly not aware of the full range of navigation options in the web-streaming interface.

Moreover, the results indicate that the ITFS respondents were indifferent towards the distance class being presented in one window (M=2.13, S.D.=0.91), whereas the web-streaming respondents tended to be between being indifferent and disagreeing with the presentation in one window (M=1.68, S.D.=1.19). This difference was statistically significant, $F(1354)=15.96$, MSE=1.12, $p<0.01$. The ITFS respondents were between being indifferent and preferring the presentation in two windows (M=2.49, S.D.=0.89), while the web-streaming respondents had a clear preference for the presentation in two windows (M=2.93, S.D.=1.00). This difference was statistically significant, $F(1354)=19.42$, MSE=0.89, $p<0.01$. Overall, the results indicate that web-streaming respondents had fairly strong preferences for the video

presentation in two windows, whereas the ITFS respondents appear to not have strong preference for either one- or two-window presentation.

4.5. Interaction with instructor and fellow students

Table 4 presents the results for the six survey items relating to the interactions among students and between the student and the instructor. The results indicate that there were no statistically significant differences in the attitudes of the ITFS and web-streaming respondents, except for the survey item relating to asynchronous communication.

All participants perceived the opportunities to interact with the instructor as only slightly sufficient in the DE video courses that they had taken (overall M=2.35, S.D.=1.18). The opportunities for interaction with fellow students were perceived as mediocre (overall M=1.94, S.D.=1.21). The web-streaming respondents had somewhat more positive attitudes toward the opportunities for interaction with the instructor and the fellow students that they had experienced, although the differences were not statistically significant. The real-time communication with the instructor was perceived as being of low importance (overall M=1.91, S.D.=1.05), while the respondents had a distinct preference for interacting with the instructor after watching the class video (overall M=2.88, S.D.=0.87). Online activities enhancing the class were valued as somewhat beneficial (overall M=2.24, S.D.=1.13). The web-streaming respondents (M=2.51, S.D.=1.04) perceived asynchronous communication with the instructor and fellow students in DE classes as more beneficial than the ITFS respondents (M=2.27, S.D.=0.89) and this difference was statistically significant, $F(1354)=5.38$, MSE=0.93, p=0.02.

Overall, these results indicate that the respondents deemed synchronous interaction with the instructor as being of low importance and expressed a significant preference for asynchronous interaction with the instructor. This finding is consistent with the significant preference for watching the class video

Table 4
Student and instructor interactivity

Survey statement	Overall (N=356)		ITFS (N=177)		Web-streaming (N=179)		ANOVA		
	M	S.D.	M	S.D.	M	S.D.	F(1354)	MSE	p
There were sufficient opportunities to interact with the instructor.	2.35	1.18	2.28	1.18	2.42	1.18	1.40	1.39	0.24
There were sufficient opportunities to interact with fellow students.	1.94	1.21	1.84	1.18	2.03	1.24	2.38	1.46	0.12
I prefer to ask the instructor questions in real time, e.g., phone in while the class is being taught on campus.	1.91	1.05	1.98	1.04	1.85	1.06	1.33	1.10	0.25
I prefer to ask the instructor questions after watching the video, e.g. email or phone call during office hours.	2.88	0.87	2.82	0.88	2.94	0.87	1.51	0.76	0.22
Online activities (e.g., team work) enhance distance class.	2.24	1.13	2.16	1.15	2.31	1.10	1.45	1.27	0.23
I would enjoy to participate in asynchronous communication with fellow classmates and the instructor.	2.39	0.97	2.27	0.89	2.51	1.04	5.38	0.93	0.02*

* Denotes statistically significant difference between ITFS/cable TV and web-streaming.

asynchronously from the on-campus class schedule, as shown in Table 2. The preference for asynchronous interactions is also consistent with the preference for participating in asynchronous communication. This could be achieved by integrating discussion boards, also known as bulletin board systems (BBS), into the DE course web site, and it appears that the effective utilization of these bulletin board systems for meeting the need of the students for interactivity should be examined in more detail.

4.6. Effectiveness of video distance education

Table 5 shows the results for the nine survey items relating to the overall perceived effectiveness of the distance education video courses. There were no statistically significant differences between the attitudes of the ITFS and the web-streaming respondents towards the overall effectiveness of the DE video courses. All students generally perceived that they learned a lot from the class videos (overall M=3.01, S.D.=0.89). Furthermore, they perceived that the video received via either form of video delivery provided an effective presentation of the course information (overall M=2.99, S.D.=0.97). The web-streaming respondents agreed slightly more strongly with the statement that the video helped them to stay focused during the instruction, while the ITFS respondents agreed slightly more with the statement that the video was shot to point to the most important information. All students agreed that repeated viewing helped them to learn the class materials (overall M=2.90, S.D.=0.95). This appears to be an advantage over traditional in-class instruction, where students often feel intimidated to ask for repeated explanations, which may hold up the entire class.

Both groups of respondents had approximately the same level of weak agreement with the statement that "distance education was at least as good as traditional classroom instruction" (overall M=2.69,

Table 5
Effectiveness of video distance education

Survey statement	Overall (N=356)		ITFS (N=177)		Web-streaming (N=179)		ANOVA		
	M	S.D.	M	S.D.	M	S.D.	F(1354)	MSE	p
I learned a lot from the class videos.	3.01	0.89	2.97	0.87	3.04	0.92	0.69	0.80	0.41
The information was presented effectively in the class video.	2.99	0.97	2.94	0.95	3.03	0.98	0.77	0.94	0.38
The video presentation helped me to stay focused during the instruction.	2.69	1.09	2.59	1.04	2.79	1.14	2.85	1.18	0.09
The way the class video was shot pointed me to the most important information.	2.64	1.03	2.72	0.90	2.56	1.15	1.97	1.06	0.16
Viewing the video more than once helped me to learn.	2.90	0.95	2.88	0.92	2.92	0.99	0.21	0.90	0.65
The video distance course was at least as good as a regular classroom instruction.	2.69	1.20	2.67	1.14	2.72	1.26	0.15	1.43	0.70
I would recommend video distance education courses to others.	3.10	1.00	3.13	0.94	3.08	1.06	0.24	1.00	0.63
Overall video distance education course was worthwhile.	3.18	0.96	3.20	0.91	3.15	1.00	0.27	0.91	0.60
How challenging is distance education compared to the regular classroom?	1.08	0.65	1.00	0.67	1.17	0.62	6.02	0.42	0.02*

 * Denotes statistically significant difference between ITFS/cable TV and web-streaming.

S.D.=1.20). It should be noted, however, that the responses to this survey item had a relatively high variability, indicating relatively large differences in the attitudes of the individual students. Based on their experience, both groups of respondents stated approximately equally that they would recommend video distance education to others (overall M=3.10, S.D.=1.00). Overall, the respondents perceived distance education courses as worthwhile. The overall mean for this item was M=3.18 (S.D.=0.96), which was the highest score among all the items relating to the effectiveness of the video distance education. The responses to these latter three survey items indicate that the respondents from both compared forms of DE video delivery had approximately the same level of overall satisfaction with their distance education experience. This result is interesting given the differences in attitudes towards a number of individual aspects of the video distance education as found in the preceding sections. It appears that the individual strengths and shortcomings of the two forms of video delivery average each other out in the overall assessment of the students' distance video education experience.

The students were also asked to indicate how challenging they rate attending a distance education class in comparison to regular classroom instruction. The survey asked the students to select the answer from the options "less challenging than regular classroom instruction" which was scored as 0, "as challenging as regular classroom instruction" which was scored as 1, and "more challenging than regular classroom instruction" which was scored as 2. There was a statistically significant difference between the two groups in their perception of the challenge posed by attending a distance education class in comparison to attending regular classroom instruction, $F(1354)=6.02$, MSE=0.42, $p=0.01$. While the ITFS respondents found the distance education as challenging as regular classroom instruction, the web-streaming respondents found the distance education more challenging. This result is interesting as it is in contrast to the essentially identical scores from both groups on the preceding three items relating to the overall effectiveness and satisfaction with the video distance education course. The survey item about the level of challenge may reflect that the web-streaming students had to struggle with the lower video quality and more technical difficulties. These shortcomings of the web-streaming may be compensated by the more positive attitudes of the web-streaming respondents towards the items relating to the anytime/anywhere web delivery with good control of the instructional flow. This compensation effect may be one explanation for the almost identical overall satisfaction levels in both groups of distance learners.

To obtain further insight into the overall attitudes of the respondents towards the various aspects of video distance education, the five statements with which the 356 respondents agreed most strongly and the five statements with which the respondents agreed least strongly are shown in Table 6. (The survey item about the level of challenge of distance education is not considered in this ranking as it was rated on a 3-point scale. Also, the item about technical difficulties is not considered as it was formulated as a negative statement, while all other survey items were formulated as positive statements.).

The table reveals that the respondents showed the strongest levels of agreement with the statements relating to the anytime/anywhere convenience of distance education, the control of the instructional flow, and the navigation of the video. These results underscore once more the preferences of the respondents for flexible on-demand education at a time and place that fits the schedule of the students. Also, the very strong preferences for control and easy navigation seem to indicate that students prefer to take the notion of on-demand education to the level of selectively navigating and viewing portions of the class video according to their personal educational needs.

It is interesting to observe that two items relating to the overall satisfaction with the video distance education rank among the top five highest ranked statements. This result seems to indicate that despite

Table 6
Items with highest and lowest agreement

Highest agreement			
Rank	Survey statement	M	S.D.
1	I liked the anytime/anywhere convenience of taking a video distance education course.	3.57	0.78
2	I liked having control over the instructional flow (e.g., go back, forward the video).	3.44	0.75
3	It was convenient to fast forward/rewind the video to a specific part of class.	3.20	0.96
4	Overall, video distance education course was worthwhile.	3.18	0.96
5	I would recommend video distance education courses to others.	3.10	1.00

Lowest agreement			
Rank	Survey statement	M	S.D.
23	Online activities (e.g., team work) enhance distance class.	2.24	1.13
24	There were sufficient opportunities to interact with fellow students.	1.94	1.21
25	I prefer to ask the instructor questions in real time, e.g., phone in while the class is being taught on campus.	1.91	1.05
26	I prefer to have one presentation window for the video (switching between instructor and content slides).	1.90	1.08
27	I prefer to watch the video in real time while the class is being taught on campus.	1.82	1.21
28	I prefer the video delivery on videotape.	1.74	1.25

the various shortcomings of distance education, such as insufficient opportunities to interact with fellow students and limited opportunities to interact synchronously with the instructor, as well as the technical problems and insufficient video quality (in the case of web-streaming), the respondents were overwhelmingly positive about their distance education experiences. It appears that the convenience of personalized on-demand education that comes with distance education outweighs its drawbacks and gives rise to overall highly positive student attitudes towards video distance education.

The lowest rated item relates to the video delivery on video tape, which the received open comments indicate is perceived as old fashioned by the students who also indicated that they would rather want to have an option for video delivery on DVD. Among the lowest rated items were also the two items relating to watching the class synchronously with the on-campus class schedule and interacting during the on-campus class with the instructor. These preferences are consistent with the top ranking for the anytime/anywhere survey item. Interestingly, the preference for having one presentation window received one of the lowest overall ratings, indicating that students would rather not see an alternating view of instructor and writing pad/presentation slides in the same window. The preference for class enhancing on-line activities, while slightly positive as indicated by the average rating above 2 (which corresponds to neither agree nor disagree), is one of the lowest ranked preferences. The received open-ended comments indicate that students have mixed feelings about these online activities. As one student stated: "*I tried . . . courses that required students to post messages and responses to messages by certain dates & times. This was frustrating and counterproductive, because many students procrastinated until the very last opportunity to post messages and caused a domino effect on everyone else.*" This and similar concerns received from the students about the online activities indicate that there is a need to carefully examine how such activities are structured to fulfill the needs of the students for interaction (thus addressing item ranked 24 in Table 6) while avoiding frustration and maintaining as much as possible of the anytime flexibility.

Table 7
Most frequent answers to the question: What did you like the best about your video distance education course?

Answer	Number of students	Percentage (%)
Anytime	135	43
Personalized control of playback (pause, rw, ff)	57	18
Anywhere	51	16
Convenience	22	7
Repeated viewing for review	15	5

4.7. Open-ended questions

This section analyzes the received responses to the open-ended questions (A) "What did you like the best about your video distance education course?", (B) "What did you like the least about your video distance education course?", and (C) "Please suggest potential improvements to the use of video in distance education courses." The frequency of the constructed responses to these questions was tabulated.

Table 7 shows the answers to question (A) relating to the most positive aspects of DE video courses that were constructed at least ten times in decreasing order of frequency.

The anytime on-demand flexibility of taking the video distance learning class was entered by 135 out of the 356 students, i.e., 43% of the respondents. Similarly, the anywhere flexibility and the overall convenience were among the most frequent responses. Interestingly, the personalized on-demand control of the video playback to personalize one's pace and the repeated viewing of specific passages of the video for the purpose of review of the explanations of specific concepts were among the most frequent responses. This underscores once more the desire for on-demand education which implies that students prefer to customize the viewing of the individual portions of a given DE class video.

Table 8 presents the answers to question (B) relating to the least positive aspects of DE video courses that were constructed at least ten times.

The insufficient interaction with the instructor was the most frequent response, also the insufficient interaction with fellow students was noted frequently, which is consistent with the low ranking of the related survey item in Table 6. Interestingly, the students quite frequently noted the required self-discipline as the least liked aspect of distance education. Clearly, the asynchronous form of distance education requires a careful balance between anytime flexibility on one hand, and the necessary self-discipline to complete class work by certain deadlines on the other hand. It appears worthwhile to examine in more detail how study guides that are tailored for each class and provide the students with

Table 8
Most frequent answers to the question: What did you like the least about your video distance education course?

Answer	Number of students	Percentage (%)
Insufficient interaction with instructor	40	14
Video quality problems	26	9
Insufficient interaction with students	25	8
Required self discipline	23	8
Video streaming problems	15	5
General technical difficulties	14	5

"best practices" on time management for the class could aid in alleviating the concerns of the students about the required self-discipline while leaving room for anytime flexibility. Interestingly, three of the most frequent responses related to the video quality and the technical aspects of the video delivery. These results highlight once more the need for the video delivery technology, in particular the web-streaming technology, to mature and become more user-friendly.

Table 9 shows the responses to question (C) relating to possible suggestions for improvement of DE video courses that were constructed at least five times.

A wider selection of courses offered in the distance learning format is one of the most frequently noted desires. The received open-ended comments indicate that especially those students who live far from campus and rely exclusively on distance education feel restricted by not having all courses of their respective program offered in the distance learning format. The wishes for improved video quality and interaction with instructor and fellow students are consistent with the most frequently noted weaknesses of distance learning, see Table 6. Interestingly, the respondents quite frequently noted that it would be beneficial if the students who are in the classroom studio as the class video is being captured would always turn on their microphones when asking a question so that the student audio is captured on the video recording. Alternatively, the instructor should repeat the question into the instructor microphone, or the student microphones should be controlled by the technicians operating the video cameras.

Other specific improvements that were frequently noted are the following. For classes that were recorded in an earlier semester, the students would prefer to receive the entire collection of class videos in high video quality at the beginning of the semester on a CD-ROM or DVD. This would permit convenient replay on a variety of devices including laptop computers and TV sets and avoid the bandwidth constraints imposed by the Internet on the web-streaming video and the quality of the Internet delivered video.

Another area of improvement frequently asked for by the respondents is to conduct all class business, including exams, homework assignments, and class projects online. Related is the request to reduce the delays in the return of graded materials, which involved shipping via university intra-mural mail and regular postal mail. The delays due to the shipping could clearly be eliminated by conducting the class business on-line and the students could receive more prompt feedback on their work.

Finally, the respondents noted that the instructor and the video production team should work more closely together to ensure the most important parts of the class are captured in the class video. Especially for asynchronous distance education video, where the class video can be edited before providing it to the

Table 9

Most frequent answers to the question: Please suggest potential improvements to the use of video in distance education courses

Answer	Number of students	Percentage (%)
More classes online (variety)	13	7
Improve video quality	13	7
Improve interaction with instructor	11	6
Better use of microphones by students (or room control)	10	5
Provide CD/DVD with videos	7	4
All class business (including exams, homework) online	6	3
Shorter delays in grading	5	3
Improve interaction with students	5	3
Better cooperation between instructor and video production team	5	3

students, the students recommended that the class should be recorded in parallel by the various cameras in the classroom studio. All the recorded video material should then be taken into consideration when composing the final class video and the instructor and video production team should jointly select the most appropriate camera views (shots).

5. Conclusions

The authors have conducted a large-scale evaluation study of the attitudes of students towards the ITFS/cable TV video delivery and the web-streaming video delivery of distance education classes. The survey responses of a group of close to 180 ITFS/cable TV students were compared with the responses of a group of close to 180 web-streaming students. The analysis of the survey responses indicates that the overall satisfaction of the respondents with the video distance education is approximately the same for both forms of video delivery. However, there are a number of significant differences in the attitudes of the two groups of respondents towards individual aspects of the distance education video. The web-streaming respondents perceived the video quality statistically significantly lower and perceived statistically significantly more technical difficulties than the ITFS/cable TV respondents. The web-streaming respondents, on the other hand, had statistically significantly stronger preferences for watching the class video asynchronously from the on-campus class time and had statistically significantly stronger preferences for controlling the instructional flow by going back and fast forwarding the class video. The web-streaming respondents also perceived the control of the video playback as somewhat more convenient and the structure of the class video as somewhat clearer than the ITFS/cable TV respondents. While the ITFS/cable TV respondents perceived the video distance learning classes as being as challenging as regular classroom instruction, the web-streaming respondents perceived the distance education classes as statistically significantly more challenging. Interestingly, these individual differences appear to average out when respondents assess their overall satisfaction with their video distance education experience.

This evaluation study revealed areas in video distance education that from the student perspective need improvement. For the web-streaming video delivery, improved video quality and more mature technology with fewer technical problems were the foremost concerns of the respondents. Overall, the respondents wished a larger variety of classes was offered in the distance learning format and that the student–instructor as well as the student–student interaction was improved.

Overall, this evaluation study indicates that with the present web-streaming technology, there is no advantage in terms of the overall perceived student satisfaction over the ITFS/cable TV video delivery. As the web-streaming technology matures to allow for the streaming of higher-quality video with a more user-friendly technology, it appears that the web-streaming video delivery has the potential to lead to overall increased perceived satisfaction of the distance learners.

Another underlying trend revealed by this study is that distance learners have strong preferences for personalized on-demand education, which manifested itself in the strong preferences for anytime and anywhere flexibility in the viewing of the video class material, as well as the navigation of the video of a given class. Against this background it appears worthwhile to explore the impact of on-demand flexibility in the form of video delivery, i.e., the students having the option to select from different forms of video delivery for a given distance learning course. With such on-demand video delivery format, students may choose to participate in certain lectures synchronously via the ITFS/cable TV system when

their personal schedule permits, and may choose to watch other lectures asynchronously via web-streaming when they have time or location constraints. The assessment of the student attitudes towards such on-demand video delivery forms appears to be an interesting avenue fur future research.

Another direction for future research is to conduct controlled longitudinal experiments that take student achievement into consideration. Controlled experimental design studies with a random assignment of students into the two distinct forms of distance education video delivery would address some of the limitations of the present naturalistic evaluation study. It would be desirable to examine the impact of web-streaming versus ITFS/cable TV on student performance and attitudes within a given content area and with the same instructor.

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