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RESEARCH ARTICLES

Asynchronous Video Streaming vs. Synchronous Videoconferencing for Teaching a Pharmacogenetic Pharmacotherapy Course

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Objectives. To compare students' performance and course evaluations for a pharmacogenetic pharmacotherapy course taught by synchronous videoconferencing method via the Internet and for the same course taught via asynchronous video streaming via the Internet.

Methods. In spring 2005, a pharmacogenetic therapy course was taught to 73 students located on Amarillo, Lubbock, and Dallas campuses using synchronous videoconferencing, and in spring 2006, to 78 students located on the same 3 campuses using asynchronous video streaming. A course evaluation was administered to each group at the end of the courses.

Results. Students in the asynchronous setting had final course grades of 89% ± 7% compared to the mean final course grade of 87% ± 7% in the synchronous group ($p = 0.05$). Regardless of which technology was used, average course grades did not differ significantly among the 3 campus sites. Significantly more of the students in the asynchronous setting agreed (57%) with the statement that they could read the lecture notes and absorb the content on their own without attending the class than students in the synchronous class (23%; chi-square test; $p < 0.001$).

Conclusions. Students in both asynchronous and synchronous settings performed well. However, students taught using asynchronous videotaped lectures had lower satisfaction with the method of content delivery, and preferred live interactive sessions or a mix of interactive sessions and asynchronous videos over delivery of content using the synchronous or asynchronous method alone.

Keywords: video streaming, videoconferencing, pharmacogenetics, distance learning, synchronous, asynchronous, Internet-based course, WebCT, virtual learning

INTRODUCTION

Many new schools of pharmacy have been established and many existing schools of pharmacy are increasing class size and opening satellite campuses in an attempt to alleviate the shortage of pharmacists. Distance-education technology[1] such as online courses, interactive videoconferencing, videotaped lectures, and audio-taped lectures are used to deliver pharmacy courses to an increasing number of students.[2] Distance education is defined as "a separation in time and/or space between the learner and the instructor." However, in using these technologies, the quality of instruction and the ability of students to master course outcomes should be kept in mind and assessed as these technologies are used.[3] Several studies have examined the use of synchronous videoconferencing in pharmacy education.[1-2,4-13] Interested readers are referred to a recent study on the use of synchronous videoconferencing by Kidd et al.[2] These studies mainly focused on and assessed synchronous videoconferencing as a content delivery tool and did not find a significant difference in the students' course grade among main and satellite campuses. For instance, MacLaughlin et al[7] reported their assessment of using synchronous videoconferencing lectures delivered via Internet to multiple campuses at the Texas Tech School of Pharmacy and found no difference in learning outcomes of several pharmacotherapy courses between local and distant students. Ried et al assessed video streaming via Internet as a content delivery tool at the College of Pharmacy, University of Florida, and found that students on the founding campus and distant campuses performed equally well.[8]

The Texas Tech School of Pharmacy uses synchronous videoconferencing to deliver a large portion of the curriculum in the first, second, and third year of pharmacy studies to 3 campuses located in Amarillo, Lubbock, and Dallas. In response to shortage of pharmacists in Texas, the Texas Tech School of Pharmacy is opening a fourth

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campus in the city of Abilene (a 4-year PharmD program with identical curriculum). The School will admit an additional 40 students for the new site in fall 2007. This campus addition creates new challenges for the School for course delivery and efficient use of resources; therefore, the School is considering asynchronous video streaming instead of synchronous videoconferencing as a method of content delivery to all 4 sites. Additional reasons for the School's decision to move towards asynchronous video streaming instead of synchronous videoconferencing were to: (1) address the lack of faculty confidence in and satisfaction with the current synchronous videoconferencing system, (2) provide a means for students who failed courses to review specific content on recorded videos and achieve the level of learning required before taking comprehensive second-chance examinations; (3) enhance the student's abilities as self-directed and life-long learners; and (4) implement and/or experiment with a change in didactic course delivery as a strategy approved by faculty in the School's strategic plan to improve students' learning outcome.[14]

Regardless of the method of content delivery used (whether asynchronous video streaming, synchronous videoconferencing, or live lectures), in order to produce optimal learning, there must be a balance between the 3 main types of learning: the cognitive, affective, and psychomotor domains.[7,15] The cognitive domain involves development of knowledge, comprehension, application, analysis, synthesis, and evaluation. The affective domain deals with student emotions. This includes student's feelings, appreciation, enthusiasms, motivations, values, ethics, and attitudes. The psychomotor domain involves the development of motor activities, such as physical movement and coordination. This study asked questions related to the first 2 types of learning. The objectives of this study were: (1) to compare academic performance, as measured by mean average grade in the *Pharmacogenetic Pharmacotherapy* course when delivered to multiple campuses by asynchronous video streaming in spring 2006 versus synchronous videoconferencing in spring 2005, (2) to investigate whether students are able to self-direct their own studies using asynchronous video streaming versus synchronous videoconferencing; and (3) to evaluate student perceptions and feelings towards asynchronous versus synchronous content delivery.

METHODS

The guidelines for manuscripts describing instructional design or assessment[16] were followed in the preparation of this manuscript.

Pharmacogenetics Pharmacotherapy is a 1-credit hour course that is delivered to third-professional year pharmacy students at the Texas Tech School of Pharmacy. This course is offered and delivered 4 days a week during January. The course is organized into twelve 65-minute lectures. Each credit hour course requires 800 minutes of contact time.

The Texas Tech School of Pharmacy is a multi-campus teaching institution located in 3 cities of Amarillo, Lubbock and Dallas. Students completed their first 2 years of pharmacy education at the main campus in Amarillo. Then they were assigned to Dallas (370 miles), Lubbock (120 miles), or Amarillo for their third- and fourth-professional years. Of the 78 students who enrolled in the *Pharmacogenetics Pharmacotherapy* course in spring 2006, 30 students were located at the Dallas campus, 18 at the Lubbock campus, and 30 at the Amarillo. The main reason for distribution of the students to satellite campuses was the limited number of experiential and clinical rotation vacancies available in Amarillo. Seventy-three students enrolled in the pharmacogenetic course in spring 2005 and were similarly assigned to 1 of the 3 campuses.

Synchronous videoconferencing of an instructor using a *PowerPoint* presentation was employed as the method of content delivery in spring 2005. There were opportunities for students from all campuses to interact with the instructor from the main campus during each session. Only 1 instructor was involved in teaching the course and evaluating students. Lectures were initiated in Amarillo and delivered synchronously to Dallas and Lubbock campuses by *HealthNet* via the Internet. *HealthNet* is a University-owned support system that provides synchronous videoconferencing services using *Pixion* software (http://www.pixion.com) for transmitting audio and visual signals across the Internet for course delivery. The service was supported by the Information Technology Department of Texas Tech University Health Sciences Center. The *HealthNet* videoconferencing system is used for teaching first- and second-professional year pharmacy students at the Texas Tech School of Pharmacy when lectures are initiated from satellite campuses in Dallas and Lubbock.

The lecture materials for the *Pharmacogenetic Pharmacotherapy* course were posted on *WebCT*, an online course delivery tool (http://www.webct.com), at least 3 days in advance of lectures. Supplementary optional readings were provided on *WebCT* to enhance students' learning. *WebCT* also allowed student assessments and grades to be posted in a timely manner with accessibility from any location. In total, 2 review sessions were held during the course. For each review session, a *PowerPoint* presentation was prepared, including important slides from the previous 5-6 lectures. Simple questions on important information were asked from time to time during

review sessions to help focus students' attention on course materials. Question-and-answer sessions were held during the review and regular lecture sessions by asking a student from one of the 3 campuses to answer the first question. The student would then call on a student from a different campus to answer the next question. The method was adopted as an active-learning component of the course in spring 2005 to encourage and engage students from all 3 campuses in the discussion.

The same instructor was involved in delivering the course in spring 2006. Lecture notes, videocasts, and optional supplementary reading materials were posted on *WebCT* at least 3 days before web casting. During the first session, the instructor had a 20-minute synchronous videoconferencing session with students from all 3 campuses using the *HealthNet* system during which the instructor provided a brief outline of the course, examinations, how to use the videocasts, a brief introduction to the course objectives, and a few examples from pharmacogenetics and variability in drug response. Students were advised to view the videocasts at their convenience before attending subsequent review sessions, which were held on the third scheduled lecture time during the course. In total, 4 review sessions were held using synchronous videoconferencing via the Internet. Attendance at the first 3 review sessions was not mandatory, mainly because the time allocated to the review sessions would have been beyond the 800-minute requirement for a 1-credit hour course contact time. For each review session, a *PowerPoint* presentation that included important slides from the previous 3 video lectures was prepared. To assist students in focusing on the most important information, simple questions were posted on each slide used in the review sessions. A question-and-answer format was used throughout the first 3 review sessions in a similar manner to previous years. A lecture was given to the students on the last review session using synchronous videoconferencing via the Internet and attendance was mandatory to fulfill the contact time requirement for a 1-credit hour course. The videocast for this session was posted on *WebCT* for subsequent viewing by the students. An example of the work "The Application of Pharmacogenetics in Clinical Medicine" is available at the following link: http://www.ttuhsc.edu/sop/Moridani/default.aspx.

Students were required to have a laptop computer. The required software was installed on the students' computers by an onsite computer support center during the first week of classes in the first-professional year. Broadband Internet access is necessary to view videocasts and/or to download course *PowerPoint* and PDF files from home. Students who did not have broadband Internet access from their home had to view videocasts using school Internet ports. There was an Internet port available for each student in the class. Each campus was also equipped with wireless Internet access.

The classroom in each of the 3 campuses was equipped with a camera, computer, monitor, VCR, document camera, large screen for *PowerPoint* presentations, and television monitor for visual interaction between students and instructor. The instructor was able to view the students from other campuses on the monitor. Students' desks were equipped with remote touch-sensitive microphones. When a student microphone was activated, a video camera focused on the student asking the question and the video image on the monitor and the audio source switched from the instructor to the student. All students could view each other at multiple campuses when asking questions or during discussion periods. Technicians were available onsite on all campuses to provide technical support before and during synchronous videoconferencing.

Materials from the previous year were used without any additional content to prepare videocasts. The important information on slides were highlighted using color-coded arrows, text, and boxes. Each *PowerPoint* presentation lecture was broken in to 3 sections and videotaped using a 1.3 *Megapixel* Logitech *WebCam* connected to a Dell D500 series laptop using Logitec *QuickCam* software. The length of each video section varied between 10-30 minutes based on the natural break of content during lectures. A number of self-assessment questions were incorporated in the videocasts to reinforce learning and promote critical thinking and problem solving (similar questions were asked during the previous year in synchronous videoconferencing). After viewing the videos, a list of deficiencies were identified for editing the product. Sony *Vegas 6* software was used for editing the program. The videotaping, reviewing, and selection of the materials were performed by the instructor in his office. The final editing was performed by the Center for Teaching and Learning with Technology (CTLT) at the Texas Tech School of Pharmacy, Amarillo, Texas. Microsoft *Windows XP, Internet Explorer 6.0* or later, and *Windows Media Player, Version 10* were needed to view the videos.

The level of background noise from the conversations in adjoining rooms and in corridors, and interruptions by visitors were contributing factors in making the time required to complete the project excessive. Each video session was taken and reviewed 2-3 times. The edited product was reviewed and edited slightly as well. The quality of audio and visual signals was acceptable from a technological perspective. The instructor was satisfied with the final product; however, there was still room for improvement by working on the quality of light, sound, and background noise during video recording in the office.

Students who completed the course through synchronous videoconferencing via the Internet were assessed by a mid-term examination worth 45% of their total grade, and a final examination worth 55%. The final examination was cumulative. Ten percent of the final examination score was based on test material from the first half of the course. Both tests were administered in a paper format and graded using a scantron machine.

Students who completed the course through asynchronous video streaming via the Internet were assessed by a midterm examination worth 40%, a final examination worth 50%, and an essay assignment worth 10% of the final grade. The final examination was cumulative. 10% of the total 100% on the final examination was from the first portion of the course. The essay assignment was introduced to the course in spring 2006 to add an active-learning component, and to train and encourage students to use PubMed (http://www.ncbi.nlm.nih.gov/entrez/) for evidence-based medicine and new information on pharmacogenetics and the application of pharmacogenetics in clinical medicine. Both tests were administered in a paper format and graded using a scantron machine. The instructor provided the keywords for essay assignment to students for subject searches on PubMed. Examples of the search terms used were *CYP2D6* and *pharmacogenetics*, and *TPMT* and *pharmacogenetics*. Each subject was assigned to a team of 2 students. The students were asked to prepare a 4-6 page report on the subject by summarizing literatures found on PubMed and in primary journals.

Students were supported by telephone, e-mails (all campuses), and office visits (Amarillo campus only) during both academic years. The questions-and-answers were posted on discussion board designated to the *Pharmacogenetic Pharmacotherapy* course on *WebCT*.

WebSurveyor (http://www.websurveyor.com) was used to post survey questions 1 week after addressing the students' questions and concerns on the final examination and after releasing final grades. An e-mail message inviting students to participate in the survey was sent. Two reminder e-mails were subsequently sent to students requesting participation in the survey. The responses were collected 4 days after posting the survey. The survey instrument included questions related to the methods of content delivery, review sessions, course evaluations, and an open-ended question for students' additional input about the course. For questions asked on the surveys see Tables 1 and 2. Survey results are described in Table 1, Table 2, and Figures 1-2.

The survey instrument did not ask and/or store any personal identification information such as first name, last name, e-mail address, address, Internet provider address, or computer information. It was not possible to link any of the responses to a specific student.

Student's unpaired *t* test (two-tails) was used to compare the grades of students in the synchronous class versus the asynchronous class using an *Excel* spreadsheet. Two-way ANOVA was used to compare students' grade among multiple campuses within the class and between the asynchronous and synchronous classes. Chi-square test (table 2×5) was used to compare the responses to questions in Table 1 (number of students who selected strongly agree, agree, neutral, disagree, and strongly disagree). The Web Chi Square Calculator (http://www.georgetown.edu/faculty/ballc/webtools/web_chi.html) was used for the chi-square calculation. A p value less than 0.05 was considered scientifically and statistically different. A web based Sample Error Calculator (http://www.dssresearch.com/toolkit/secalc/error.asp) was used to calculate sampling error, an error that is introduced to the observation as a result of sample size (number of students who participated in the survey).

RESULTS

Sixty-eight of 78 students from the asynchronous video streaming class responded to the survey (response rate = 87%). Forty-one of the 48 students from satellite campuses participated in the survey (response rate = 85%). Response rates from Amarillo, Lubbock, and Dallas ranged from 83%-90%. The response rate was significantly lower among students in the synchronous videoconferencing class (43%) than in the asynchronous video streaming class (87%). Sampling errors were calculated to estimate the error of observation as a result of sample size/response rate in the study. At a confidence interval of 90%, response rate of 87%, and a sample size of 68, the sampling error was calculated to be 2% for survey results obtained from the asynchronous video streaming class. In other words, the responses received from a sample size of 68 out of 78 students are truly representative of the entire class with a margin error of 2%.

For students from the synchronous videoconferencing class, at a confidence interval of 90%, response rate of 43%, and a sample size of 31, the error was calculated to be 11%. In other words, the responses received were within 11% of the true response if all the students in the synchronous class had participated in the survey. As is evident, the sampling error for the asynchronous class was 2%; whereas, for the synchronous class, the sampling error was 11%. Clearly, a sample size of 68 out of 78 provided a true representation of the asynchronous video class, because the response rate was higher. In contrast, a degree of limitation (error of 11%) is introduced to what can be inferred from the responses received from the synchronous video class, mainly because a smaller group of students participated in the survey.

Table 1. Comparison of Responses Regarding Content Delivery, Review Sessions, and Course Evaluation from Students in a Pharmacogenetic Pharmacotherapy Course Taught Using Synchronous Videoconferencing* and Students in a Course Taught Using Asynchronous Video Streaming†

Survey Statement	Class/Method of Video Delivery	Percentage					5-Point Scale (Mean)‡	*P*§
		SA	A	N	D	SD		
Content delivery								
1. Because of availability of lecture materials on WebCT, I can read the lecture notes and absorb the content on my own without attending the class.‖	Synchronous	10	13	26	39	13	2.7	<0.02
	Asynchronous	13	44	16	7	19	3.3	
Review session								
1. Attending review sessions made a difference in my learning experience.	Synchronous	16	52	23	10	0	3.7	<1
	Asynchronous	16	43	28	6	7	3.5	
2. Review sessions were useful in re-enforcing my understanding of the subject for my future use.	Synchronous	13	52	29	7	0	3.7	<1
	Asynchronous	13	55	27	3	2	3.8	
3. The question-and-answer sessions during review sessions was a good method for active learning.	Synchronous	16	48	26	10	0	3.7	<0.2
	Asynchronous	9	53	25	3	10	3.5	
4. The question-and-answer session should be exercised during review sessions in the future.	Synchronous	32	36	23	7	3	3.9	<1
	Asynchronous	19	47	24	2	9	3.7	
5. During review sessions, there was an equal opportunity to participate in the discussion from all campuses.	Synchronous	19	58	16	7	0	3.9	<1
	Asynchronous	18	66	13	0	3	4.0	
Course evaluation								
1. This course was well organized.‖	Synchronous	3	68	13	10	7	3.5	<0.05
	Asynchronous	13	68	18	0	2	3.9	
2. The information/concept/principles in this course prepared me to identify and solve problems.‖	Synchronous	7	58	29	7	0	3.7	<0.05
	Asynchronous	10	78	10	2	0	4.0	
3. Course materials (videos, notes, exercise, etc) enhanced my learning.	Synchronous	10	68	16	7	0	3.8	<1
	Asynchronous	22	63	10	2	3	4.0	
4. Supplementary reading articles, which are attached to the course syllabus, enhanced my learning.	Synchronous	13	16	65	7	0	3.4	<0.2
	Asynchronous	5	16	58	8	13	2.9	
5. The font size on lecture notes was large and I had no difficulty reading the slides on the screen.	Synchronous	16	61	19	3	0	3.9	<1
	Asynchronous	29	59	9	3	0	4.4	
6. The assessment methods (exams, papers, etc) were appropriate.	Synchronous	10	71	10	10	0	3.8	<1
	Asynchronous	13	68	12	2	6	3.8	

SA = strongly agree, A = agree; N = neutral; D = disagree; SD = strongly disagree

*Response rate = 43% (31 out of 73 students enrolled in the course in spring 2005 responded to the survey)

†Response rate = 87% (68 out of 78 students enrolled in the course in spring 2006 responded to survey)

‡Calculation of average response for each question: number of students who selected each response was multiplied by the numerical scale rating for that response (strongly agree = 5; agree = 4; neutral = 3; disagree = 2; and strongly agree = 1); the 5 totals were then added together and the sum was divided by the number of students who answered that question

§Comparisons were made using Web Chi Square Calculator (http://www.georgetown.edu/faculty/ballc/webtools/web_chi.html). The numbers of students that selected each response were compared to the other class

‖Significantly different from survey results obtained from the interactive videoconferencing class ($P < 0.05$)

The average grade for students in the synchronous videoconferencing class was 87% ± 7% (range 70%-100%). The average grade for students in the asynchronous video streaming class was 89% ± 7% (range 72%-100%). Although significant (two-tailed *t* test; $p = 0.05$), the 2% change in the average grade was not considered a significant improvement in students' academic performance. There was no significant difference in the average grade for the students among the 3 campuses within the class and between the asynchronous or synchronous classes (two-way ANOVA, $p > 0.05$).

The survey results for the synchronous videoconferencing class are presented in Table 1. The survey results for the asynchronous video streaming class are presented

Table 2. Responses From Students Enrolled in a Pharmacogenetic Pharmacotherapy Course Delivered by Asynchronous Video Streaming to Additional Survey Items Regarding Content Delivery

Statements Regarding Content Delivery*	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	5 point† scale
1. Watching the videos made a difference in my learning experience.	18	43	16	7	16	3
2. I prefer video casting because I can watch them whenever I have time and because I do not have to travel to the campus to attend the lecture.	26	26	13	21	13	3
3. I am based at Lubbock or Dallas. Video streaming is better than interactive videoconferencing via HealthNet.	9	30	30	15	17	3

*Students in the synchronous interactive videoconferencing class 2005 were not asked to respond to these statements.
†An average response value was calculated for each question using a 5-point scale by multiplying the number of students who selected a particular response option to the following values: SA = 5; A = 4; N = 3; D = 2; and SD = 1. The values were then summed and divided by the total number of students who answered the question.

in Table 1, Table 2, and Figures 1 and 2. Students in the synchronous videoconferencing class were not asked the questions presented in Table 2 and Figures 1 and 2.

The order of the preference for content delivery methods was: live interactive lectures (no distant education) ≥ a mix of video and interactive lectures > asynchronous videocasting and/or synchronous videoconferencing (Figure 1). The data clearly indicate that students prefer live interactive lectures or a mix of video and interactive lectures over synchronous videoconferencing lectures or asynchronous videocasting. Eighty-two percent of the students viewed at least 75% of the videocasts (Figure 2). Only 12% of responders viewed less than 50% of the videocasts. One student did not view any of the videocasts. All students had access to the *PowerPoint* presentation notes.

Fifty-seven percent of students in the asynchronous class either agreed or strongly agreed that they could read lecture notes and absorb content on their own without attending the class, whereas 27% of the students disagreed or strongly disagreed with the statement (Table 1). Interestingly, the percentages were reversed for responses from students in the synchronous videoconferencing class when videocasts were not available as a method of content delivery (Table 1; chi-square $p < 0.001$). Sixty percent of students agreed or strongly agreed that viewing videocasts made a difference in their learning experience. However, there was a division in their opinions if asynchronous video streaming was better than synchronous videoconferencing (Table 2).

A significant number of students (75%) preferred synchronous videoconferencing lectures that summarized the previous 2-3 sessions during review sessions instead of question-and-answer sessions (25%). Eighty-four percent of students attended 3 or more review sessions held during regular lecture time even though attendance was not mandatory. Fifty-nine percent of students agreed or strongly agreed that attending the review sessions made a difference in their learning experiences, whereas only 13% disagreed or strongly disagreed with the statement (Table 2). Generally, there was concordance between the survey data obtained from students in the synchronous class and those in the asynchronous class (chi-square test, $P < 1$, no significant difference). Response data for the rest of questions are presented in Tables 1 and 2.

Questions and responses pertaining to course evaluations are presented in Table 1. Over 80% of students agreed or strongly agreed that the course was organized well and was intellectually stimulating. Agreement was

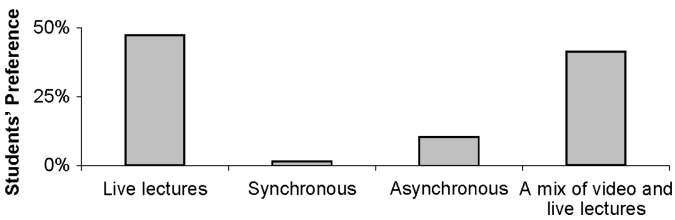

Figure 1. Pharmacy students' preferences for method of content delivery in a pharmacogenetic pharmacotherapy course (n = 68).

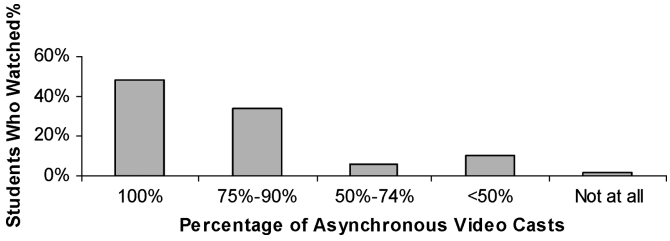

Figure 2. Percentage of students (n = 68) who viewed video materials (eg, 49% of students who participated in the survey watched 100% of the videos).

higher among students in the asynchronous video streaming class than those in the synchronous videoconferencing class (chi-square test, $p < 0.05$).

Generally, because students' response to open-ended questions are more revealing about their thoughts, perceptions, and feelings, one open-ended question was included on the survey instrument for additional input about the course from students in the asynchronous video streaming class. Approximately one third of the students who participated in the survey made positive remarks about their experience on video streaming, sufficiency of review sessions, and the appropriateness of the content. For instance, the students indicated that the course was well organized and they enjoyed the flexibility that video streaming offered (eg, they could view the materials at their convenience).

Approximately two thirds of the students in the asynchronous video streaming class made negative remarks about the learning experience. Areas of concern were the time required to view the materials; using video streaming via the Internet; lack of interaction between the instructor and students; difficulty of catching up with materials on the video; potential for miscommunication using e-mails; and lack of self-discipline on the part of the students and poor time management in viewing the videos.

Although the purpose of the review sessions was to help students learn what information was most important, some students expected answers for questions posted on the slides to be given word for word. Since the answers were usually presented on the same slide as the question but required the student to extract/interpret the information from a graph or a figure, this feedback suggests students had little desire to participate in problem solving. The comments also revealed a need for increased commitment on the part of the instructor of the *Pharmacogenetic Pharmacotherapy* course to e-mail communication and the use of Web forum discussions through *WebCT* if asynchronous video streaming is to be used as the main tool for content delivery.

DISCUSSION

There was no significant difference in grades between students in the synchronous and asynchronous video groups. Also, regardless of which technology was used, average course grades did not differ significantly among the 3 campus sites.

A significant percentage of students in the asynchronous video streaming group agreed or strongly agreed (57%) with the statement that they were "able to read and absorb the materials without attending the class" whereas the agreement was not significant among the students attending the synchronous videoconferencing class (23%). One reason might be the availability of videocasts as additional materials at students' disposal, which potentially could impact learning. Forty-three percent of the students in the asynchronous video streaming group disagreed with or were neutral toward the statement "able to read and absorb the materials without attending the class," which may indicate that the students thought the interaction between the instructor and students was important in enhancing students' learning experience. For a professional program such as pharmacy, an important component of the pharmacy curriculum is for students to learn to interact with their peers. The lack of interaction with peers in an asynchronous setting can be addressed by incorporating interactive review sessions in which students come together with each other and their instructors during the course.

Our findings indicate that students preferred to have question-and-answer sessions and/or synchronous videoconferencing lectures after independently completing every 2-3 streaming video sessions. The majority of students preferred the synchronous videoconferencing lectures as the method of interaction. For instance, on the last review session at the beginning of the class, the students were asked to choose between a question-and-answer review session and an interactive lecture providing an overview of the application of pharmacogenetics in clinical medicine. The majority of the students from the main campus and satellite campuses voted strongly in favor of an interactive lecture. Attendance during review sessions was excellent even though the sessions were not mandatory, which suggests that students preferred direct interaction with the instructor at some point during the course.

The students in the asynchronous video streaming group indicated a lower rate of satisfaction with video streaming technology than with the interactive session, possibly because the technology was newly introduced to the class and the students may have had a natural resistance to accepting this method of course delivery. Interestingly, despite a lower level of satisfaction, students from the asynchronous video group significantly agreed or strongly agreed more with the statement that the course was well organized (81%) than students from the synchronous videoconferencing group (71%) (chi-square test, $p < 0.05$). Since this was the second time the instructor had delivered the course by asynchrous video, this feedback may simply indicate that practice and experience made the course better.

With regard to the active-learning experience, critical thinking and problem-solving skills, the course had 3 components. First, the students were required to read the lecture materials and view the videocasts at their own pace. Second, various self-assessment questions

were provided to the students either throughout the videocasts or during the first 3 review sessions to assist students in evaluating their knowledge and preparing for the course. Third, an essay assignment was given to students. With regard to the active-learning experience, the majority of students preferred interactive lectures more than video streaming. Secondly, they frequently requested that the answers to the self-assessment questions be posted even though all the answers were available in the notes. Third, almost all the students disagreed, resisted, and resented the essay assignment. It seems that the students did not like active learning, critical thinking, or problem-solving skills in any format unless it was supported by a form of direct interactive session with the instructor. This finding is supported by a high attendance rate (84%) during question-and-answer review sessions. Sixty-eight percent of students also agreed that the review sessions were useful in reinforcing the materials and recommended that the sessions should be included in future classes (Table 1). However, 89% of participants agreed or strongly agreed that the information, concepts, and principles in the course prepared them to identify and solve problems.

The response rate was significantly lower in the synchronous videoconferencing class (43%) than in the asynchronous video streaming class (87%). Perhaps more students from the asynchronous video steaming class were interested in participating in the survey because the course involved a new method of content delivery. The novelty of the delivery method could have biased students' responses since there is always some resistance toward accepting new methods.

In terms of level of support with technology for course delivery, the school provided 3 options to faculty members to experiment with video recording on a voluntary basis[14]: (1) a live interactive class scheduled for the video recording of the session during regular lecture delivery time (all the steps for video recoding, editing, and posting on *WebCT* are conducted by trained staff members from the Center for Teaching and Learning with Technology (CTLT) located at the School of Pharmacy); (2) prerecording a lecture in a class room in the absence of the students. CTLT staff could conduct and process the video recording and streaming (a prior appointment with the CTLT was necessary for this option); and (3) an instructor prerecording a lecture in his/her office at a convenient time.

The author chose the third option as it provided additional time for confidence building and experimentation. In addition, it would have been easier to discontinue the project if the experience had been unsatisfactory. Although the majority of the contents were prepared previously, modifications had to be made to the *PowerPoint* presentation for better content delivery and course organization to make it suitable and worthwhile for self-study by students. On average, the time spent in preparation for each lecture was 3 days. Several difficulties were encountered during video recording, mainly because it was performed in a regular office by a faculty member with no previous on-camera experience. The lack of experience; minor acting skills required; the intensity, quality and suitability of the light; room decorations; and sound and background noise in adjoining rooms and the corridor were limiting factors experienced during the production. However, the quality of the final product was satisfactory.

In light of our findings from the *Pharmacogenetic Pharmacotherapy* course, the instructor performed a second experiment on *Clinical Toxicology*, a 2-credit hour pharmacotherapy course offered in the third-professional year. The instructor was responsible for teaching 5 lectures out of 20 on this course. The lectures were delivered using synchronous videoconferencing to the class. The lectures were videotaped, digitized without any editing within 1 or 2 days by the CTLT staff, and posted on the *WebCT* for students to view.

Students' final grades (87% $\pm$ 6%) for this course were not significantly different from grades in the previous year (89% $\pm$ 7%). However, the level of time commitment from the instructor was significantly reduced. The students' satisfaction level with the course significantly increased, mainly due to the synchronous interaction with the instructor and the availability of the instructor on site. Some of the students commented that they used the video materials when they needed them. Despite making the videocasts available, the students' attendance at review sessions was excellent.

Using in-class videotaping during synchronous videoconferencing, the materials can then be posted on *WebCT* as an additional teaching tool rather than as a mainstream content delivery tool. This obviously minimizes the level of time commitment and preparation for the faculty member. It has additional advantages for students who are not able to attend the lecture, either due to illness or advanced pharmacy practice experiences. The materials can be used to reinforce learning and to prepare students who have to take an examination a second time because of failing the course.[14]

A wealth of information related to the concept of e-learning is available in the literature and accessible through PubMed.[17] The majority of published studies are related to synchronous or non-video-based asynchronous course delivery systems supported by a web site, *Blackboard* (http://www.blackboard.com), *WebCT*

(http://www.webct.com), or other virtual learning environment. Some of the courses delivered via this technology include nursing, nutrition, financial, childbirth education, virtual patient case simulations, postpartum emotional distress, medicine, and dentistry. A limited number of studies employed asynchronous video streaming as a method for course delivery. In one study,[18] the authors evaluated the value of video lectures compared to audiotaped lectures for distance learning using an asynchronous course delivery system. They conducted a randomized controlled trial in which they showed the same slide presentation to 2 groups of students. One group saw a video of the instructor giving the lecture and the other group saw the same presentation with audio only. Their results showed that adding video to an audio presentation does not lead to greater satisfaction or greater learning. The limited information available in the literature on asynchronous video streaming gives additional value to our study since it compares 2 distance course delivery systems: synchronous videoconferencing and asynchronous video streaming.

The author is in favor of video recording in a classroom setting during an interactive session because video recording in a personal office is time consuming. Based on the experience during this study and the clinical toxicology course, the instructor will use synchronous videoconferencing on all *Pharmacogenetics Pharmacotherapy* sessions in subsequent years to increase interaction and the satisfaction of students. The synchronous videoconference lectures will be videotaped by the CTLT staff and posted on *WebCT* without editing. Attendance will not be mandatory. There will be a midterm examination worth 50% of the total grade and a cumulative final examination worth the other 50%. The midterm and final examinations will be administered on *WebCT* to avoid using a scantron machine.

As once indicated by Thomas Edison[19] in 1922, "The motion picture is destined to revolutionize our educational system and in a few years it will supplant largely if not entirely the use of textbooks." Obviously, it is taking a little longer to incorporate this technology into our educational system than Edison predicted. However, with the advent of the *Internet*, its widespread use in the last decade, and its continuing growth, Edison's prediction may eventually come true. This is because the Internet can address the 2 crucial problems required for content delivery to a large group of people using asynchrous video streaming: separation in space (eg, Amarillo, Lubbock, Dallas) and time (eg, need to view the materials in the evening or morning). Even though we seem to have overcome these 2 barriers, one must not overlook the crucial role of teachers in students' learning.

CONCLUSIONS

There was no significant difference in the students' performance when asynchronous video streaming was used in comparison to synchronous videoconferencing. When course materials were available through asynchronous video streaming, significantly more students agreed that they were able to study the materials on their own without the need to attend a class. However, students had a lower degree of satisfaction because of a limited amount of interaction with the instructor, mainly due to course delivery via asynchronous video streaming.

Asynchronous streaming videos should be used as supplementary teaching materials similar to textbooks. In the event that asynchronous video streaming is used as a mainstream tool for content delivery, review sessions should be held every 2-3 lectures to assist students with understanding course materials. Question-and-answer sessions and a brief lecture may be exercised during review sessions.

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