EVALUATION OF DISTANCE LEARNING IN AN "INTRODUCTION TO BIOSTATISTICS" CLASS: A CASE STUDY

SCOTT R. EVANS
Harvard University Extension School
evans@sdac.harvard.edu

RUI WANG
Harvard University Extension School
rwang@hsph.harvard.edu

TZU-MIN YEH
Harvard University Extension School
tyeh@hsph.harvard.edu

JEFF ANDERSON
Harvard University Extension School
janderson@sdac.harvard.edu

RAMMY HAIJA
Harvard University Extension School
rammyhaija@hotmail.com

PAUL MADOC MCBRATNEY-OWEN
Harvard University Extension School
mcbratn2@fas.harvard.edu

LYNNE PEEPLES
Harvard University Extension School
lpeeples@hsph.harvard.edu

SUBIR SINHA
Harvard University Extension School
ssinha@sdac.harvard.edu

VANESSA XANTHAKIS
Harvard University Extension School
vxanthakis@mclean.harvard.edu

NATASA RAJICIC
Harvard University Extension School
nrajicic@hsph.harvard.edu

JIAMENG ZHANG
Harvard University Extension School
jiamengz@hsph.harvard.edu

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ABSTRACT

Biostatistics is not universally available in colleges/universities and is thus an attractive course to offer via distance education. However, evaluation of the impact of distance education on course enrollment and student success is lacking. We evaluated an "Introduction to Biostatistics" course at Harvard University that offered the distance option (Spring 2005).We assessed the effect on course enrollment and compared the grades of traditional students with non-traditional students, as well as with historical traditional students (Fall 2004). We further compared course evaluations from the inaugural semester with the distance option to evaluations from the prior semester. No evidence of dissimilarities was noted with respect to overall course grade averages or course evaluations.

Keywords: *Statistics education research; Biostatistics; Distance education*

1. INTRODUCTION

Time and geographical constraints make distance education a convenient and appealing option for many students. Wegman and Solka (1999) note that distance education is a wave of the future, particularly with a recent increased emphasis on re-educating a work force engaged in a lifetime of learning. Gilmour (2002) notes that distance education courses are likely to rise with expanding access to the Internet. Increases in the number of classes offered with a distance option, and in the number of distance students, have been observed at many colleges and universities. According to a recent national survey by the Sloan Consortium (Allen & Seaman, 2005), an online education group, at least 2.3 million people took an online course in 2004 and two-thirds of institutions offering traditional undergraduate-level courses also offer online courses, and similarly for graduate-level course offerings. The Harvard University Extension School initiated a distance education program with a single course enrolling four distance students in 1997-1998. This program has grown to 55 courses offered with a distance option in 2004-2005 and 75 courses being offered in 2005-2006.

Biostatistics courses are not universally offered at colleges and universities (e.g., institutions without graduate programs in public health and/or medicine frequently do not offer courses in biostatistics). However, the demand for biostatistics courses is high due to the increasing needs of medical students, pre-medical students, public health students, as well as employees in the pharmaceutical and biotechnology industries, research hospitals, government, and academia. Thus, an "Introduction to Biostatistics" course is a particularly attractive course to offer via distance education. However, careful evaluation of the effectiveness of such a course on student learning and student evaluation is lacking.

An "Introduction to Biostatistics" course offered at Harvard University was evaluated. Grades of traditional students were compared to non-traditional students enrolled in a course open to both traditional and non-traditional students in the spring of 2005. Traditional students in the course were further compared to historical traditional students (Fall 2004) to investigate whether the distance version of the course affected the traditional students in terms of grades and evaluation scores. In addition, course evaluations for the semester in which the course was offered with a distance option (Spring 2005) and for the semster in which the course was offered only traditionally (Fall 2004) were compared.

We summarize the results of this research in the following sections. We describe the methods of delivery for distance education, discuss pros and cons associated with

distance education, and summarize prior evaluations of distance learning in statistics and biostatistics in Section 2. In Section 3, we describe the objectives and methods of our study. In Section 4, we describe the results of our study, and then conclude with a discussion of limitations, recommendations, and future research in Section 5.

2. DISTANCE EDUCATION

Although distance education has become common, its use is controversial and research suggests that its effectiveness is variable and inconsistent (Rooney et al., 2006; Rivera, McAlister, Khris, & Margaret, 2002; Li, 2002). Many research studies, whether comparison or case studies, have shown that distance learning is as favorable as classroom learning and that distance students are satisfied, and have similar grades or test results, compared to traditional students (Phipps & Merisotis, 1999; Johnson, Aragon, Shai, & Palma-Rivas, 1999; Russell, 1999; Merisotis & Phipps, 1999; Bourne, McMaster, Rieger, & Campbell, 1997; Gagne & Shepherd, 2001). A meta-analysis by Allen, Bourhis, Burrell, and Mabry (2002) demonstrated little difference in satisfaction levels of students between the traditional and distance educational formats. However, other research suggests that distance students may not be learning the material as well as those enrolled in traditional classes (Clow, 1999), and that use of the Internet merely to post materials and return homework may result in poorer learning than in traditional classes (Hiltz, Coppola, Rotter, & Turoff, 2001).

An e-mail to the group list of the American Statistical Association's (ASA) Section on Teaching Statistics in the Health Sciences (TSHS) requesting guidance from experienced distance education instructors in preparation for this "Introduction to Biostatistics" course generated numerous responses, with varying degrees of support. "Distance Education: How's it working?" was a panel discussion at Joint Statistical Meetings (JSM), 2004, and the aforementioned e-mail discussions resulted in an invited session, "Distance Learning in the Health Sciences" at JSM 2005, sponsored by the Section for TSHS. The Section on TSHS also sponsored a roundtable luncheon, "Distance Education in Biostatistics" at JSM 2005, and the Boston Chapter of ASA hosted a mini-conference on Distance Learning, "Distance Education, The Way of the Future?" Open discussions at these meetings suggested that research regarding the effectiveness of student learning in distance courses is needed. Many observations regarding the advantages and disadvantages of such courses were discussed (and are outlined in Section 2.2).

2.1. METHODS OF DELIVERY

Distance education is a very broad term that encompasses several methods of delivery. Although distance education is generally thought of as a recent development using state-of-the-art technology, correspondence courses are a form of non-electronic distance education that have been in use for many years. Typically, students register for the course and then receive a course packet including a syllabus, reading instructions, and homework problems. Completed homework assignments are sent by the student to the corresponding instructor by postal mail or fax. The instructor corrects the assignment, provides comments, and returns the graded homework. These courses are often self-paced and do not necessarily adhere to a strict semester schedule.

Online delivery has become a widely-used method due to its rapid delivery and response time. It may take the form of a lecture post in which the instructor posts a documented lecture and instructions online. Students read the lecture and then post

questions for response from the instructor and other students. It may also take the form of a lecture feed where the instructor may lecture to an attending group of students while being recorded, and then the lecture is made available for access. Videos may be made available at specified remote sites where groups of students congregate to view the video together at specified times, or online where students can individually view videos with use of the Internet. Online delivery may also be synchronized such that distance students log-on to a course website at the scheduled time of the course to view the lecture live, and can interactively communicate with the instructor while the lecture is being taught. Such courses are usually offered on a standard school semester schedule. Thus students must keep up with the lectures or risk falling behind in the course. Live chat room sessions often serve as an additional communication supplement.

A number of software tools are available to facilitate or supplement distance education, such as WebCT (Web Course Tools), Blackboard®, NetMeeting, Centra®, and Elluminate *Live!*®, and Moodle. WebCT, developed for academic use by Dr. Murray Goldberg and a group of colleagues at the University of British Columbia, and Blackboard provide many features such as announcements, bulletin boards, chat rooms, virtual classrooms, group forums, private e-mail, searching, quizzes, surveys, student home pages, glossary, syllabus, contact information, digital drop box, and gradebook (Kendall, 2001; Wernet, Olliges, & Delicath, 2000). [In February 2006, Blackboard Inc. completed a merger with WebCT Inc.]. Microsoft® NetMeeting is a Windows-based application that can be used for synchronous activities. It allows synchronous chatting, application sharing, and file sharing. Tools built into NetMeeting include whiteboard, chat, file transfer, program sharing, and remote desktop sharing. Centra® is a web-based software application that enables real-time communication collaboration and learning with features of virtual classes, web seminars, and eMeetings. Elluminate Live!® creates a real-time virtual classroom environment for distance learning and collaboration, with its many components such as two-way audio, live video, shared whiteboards, instant messaging, application sharing, and breakout rooms. Moodle, a course management system (CMS) created by Martin Dougiamas at Curtin University, Australia, is a free, open source software package designed to help educators create effective online learning communities. It has many of the above features in addition to blogs, wikis, database activities, peer assessment, and multi-language support, and can readily be extended by creating plugins for specific new functionality.

2.2. ADVANTAGES AND DISADVANTAGES

Several advantages and disadvantages associated with distance education have been identified. Many generally apply to various courses; some are of increased importance in statistics and biostatistics.

Advantages of distance education include the following:

1. There may be no alternative for many students. For example, many undergraduate colleges do not offer courses in biostatistics. Distance courses can provide the opportunity for students from such colleges to take biostatistics courses. More generally, distance education offers flexibility and convenience, allowing geographically isolated students, and students with conflicting time commitments, to continue their education. A distance option also provides students with the opportunity to take two courses that are offered at the same time. Further, the distance option may allow students the opportunity to take a course from a prominent expert in the field.

2. If the distance option includes video, then students have the ability to watch the video as many times as desired. If the student finds the course material difficult, or the student misses a class, then the video may provide a useful learning tool. Stephenson (2001) notes that distance students may take a break when tired by stopping the video, whereas students in a traditional course do not have the same luxury. Because the material is always available, students have control over the pace of learning. This can be particularly important for courses in statistics or biostatistics in which students often struggle with statistical concepts and notation.
3. Distance education may sharpen teaching skills, as both diligent preparation and careful delivery are required to teach a distance education course.
4. Successful programs of teaching statistics via distance have been documented. Speed and Hardin (2001) present the results of developing technology mediated instructional material (TMIM) for graduate level statistics courses presented to students at local and distance sites. Improvements are also possible as teachers learn how to teach, and students learn how to learn, using distance education resources.
5. Online learning may be cost effective because internet-based courses can be made available to an almost infinite number of students (Katz & Yablon, 2003b). However, cost effectiveness of using online technologies in distance education is still uncertain (Phelps, Wells, Ashworth, & Hahn, 1991), as human capital and the costs of conversion are expenses that can easily be underestimated (Ng, 2000). Carr (2001) argues that only in large courses, with many sections, would cost savings be possible. The startup costs, maintenance costs, and personnel costs should be factored in to arrive at a true cost of a distance-learning program (Valentine, 2002). Hillstock (2005) further argues that distance learning as a way to save money is a misconception. Notably, some responses to the TSHS group list indicated instructors' fear of job insecurity due to the availability of distance courses.
6. Instructors who have recorded lectures (e.g., videotapes) from prior semesters may use these recordings in future classes. This may be an attractive option when an instructor is sick or traveling, or if an instructor feels that he or she explained a topic particularly well in a specific recorded lecture.

Several disadvantages of distance education have been observed or theorized including the following:

1. Distance education may allow students to become lazy, using the online component as a crutch. A student may feel that missing a class can be justified with the availability of online videos that can be viewed at a later time. As a result, students may fall behind more frequently. This can be particularly problematic in statistics and biostatistics courses where comprehension of later concepts is conditional upon comprehension of earlier topics. Students may not be able to recover in such courses.
2. In many forms of distance education, there is no live communication between the distance student and the instructor. Many instructors feel that the face-to-face contact and the student/teacher interaction are critical to learning. Lack of this personal element also makes it more difficult for instructors to stimulate, motivate, or excite students. Students can feel a sense of isolation

and a lack of support. Students in statistics and biostatistics may need feedback on difficult concepts or computing issues.

3. Non-verbal communication such as body language and facial expressions, as well as verbal cues, cannot be conveyed with distance education. Often instructors can recognize whether a class is "getting it" by facial expressions of the students in traditional courses. The "reading" of such students is not possible in distance courses.
4. Group projects may be more difficult for distance students as it may not be possible for students to meet face-to-face. Therefore, students may not be able to learn from each other as effectively. Furthermore, there may be less satisfaction without group interaction.
5. "Asynchronous" distance students are at a time disadvantage as they do not have the opportunity to ask direct questions in a timely manner (if at all). There are typically delays in both video access and receiving graded homework assignments.
6. Technology problems may create a disadvantage for distance students. Students must often solve computing hardware or software issues on their own. Foster (2003) notes that the mathematical notation involved in biostatistics and statistics may also create technological obstacles with respect to software. Such technology issues make it difficult to provide students with equal access to course materials.
7. Distance courses may become "watered-down" because instructors (intentionally or subconsciously) may be sympathetic to the additional complications involved with distance education. This could jeopardize education quality.
8. Teaching distance education courses requires more diligence and preparation than traditional courses. Lectures need to be self-explanatory (Bruce, Bond, & Jones, 2002). Instructors often underestimate the time and resources needed for development of course materials. The volume of e-mail created from distance students may increase dramatically for the instructor and teaching assistants.
9. Institutions are often not well prepared for offering distance courses, and methods of delivery may not be sufficient for effective learning. Due to budget limitations, instructors may not have sufficient school support (e.g., funding) and access to resources for dealing with the issues created by distance education.
10. Distance education may create more problems with cheating and academic honesty. It may be more difficult to assess whether students have completed their own work.

2.3. EVALUATION OF DISTANCE LEARNING IN BIOSTATISTICS AND STATISTICS

A few evaluations of distance learning in statistics have been published. Katz and Yablon (2003a), through use of an external control group, found that students in an internet-based "Introduction to Statistics" course achieved similar grades, were characterized by a higher locus of control, and had higher motivation and satisfaction than students in a lecture-based course. Traditional students had higher levels of self-

esteem, however. Katz and Yablon (2003b) further suggest that as students gain more experience with distance learning, students become more at ease and develop positive attitudes toward this educational format.

Harrington (1999) compared grades of incoming Masters of Social Work (MSW) students in traditional versus distance statistics courses. Students with high prior grade point averages (GPAs) performed similarly regardless of registration status (distance or traditional). However, students with low GPAs performed better than traditional students.

Stephenson (2001) compared grades of distance and traditional students in an "Applied Statistics for Industry" course and found that traditional students had slightly higher grade point averages, but noted that the differences may be due to random variation.

McGready (2006) conducted a non-randomized study comparing the exam grades of on-campus and on-line students in a "Statistical Reasoning in Public Health" course at Johns Hopkins University. The study consisted of separate independent lectures (but using the same slide set) for the distance and traditional versions of the course. The distance version of the course utilized streaming audio and synced slides. No statistically significant between-group differences were identified.

3. METHOD

3.1. INTRODUCTION TO BIOSTATISTICS

"Introduction to Biostatistics" (STAT E-102) at the Harvard University Extension School was an introduction to statistical methods course used in the public health, biological, and medical sciences. Topics included descriptive statistics, performance characteristics of diagnostic tests, graphical methods, estimation, hypothesis testing, p-values, confidence intervals, correlation, linear regression, and clinical trials. The course did not require any formal pre-requisites and was offered for graduate or undergraduate credit.

The Instructor for the course had a PhD (Biostatistics) with a primary appointment in the Harvard School of Public Health. Seven experienced Teaching Assistants (TAs) were involved with the course. Six of the TAs had master's degrees (4 Biostatistics/Statistics, 1 Epidemiology, 1 Mathematics) and one had a PhD (Biostatistics).

The course had one two-hour lecture per week (also available via video) with five optional TA help sessions offered throughout the week. Six homework assignments were collected during the semester. Graduate students also completed two projects. Grades for graduate students were determined by the midterm exam (30%), the final exam (30%), homework (20%), and the projects (20%). Grades for undergraduates were determined by the midterm exam (35%), the final exam (40%), and homework (25%).

Students were required to learn a software package of their choice. Support was provided for STATA, with weekly TA sessions (for local students only) and handouts. The course text was *Principles of Biostatistics* by Pagano and Gauvreau (2000).

The course had an extensive and active website. All course materials were posted on the website, including the syllabus, lecture notes, lecture videos, homework assignments and solutions, project assignments and solutions, computing (STATA) handouts, course announcements, and a history of questions and answers. A course e-mail distribution list provided the opportunity for students to ask questions of the TAs and communicate with other students, and further provided the TAs with the opportunity to make announcements regarding homework assignments and exams.

3.2. VIDEO DELIVERY AND DISTANCE METHODS

Lectures available on the course website used streaming video technology (i.e., video that is sent to the user as it is viewed) along with standard Internet browser software. The video window appeared on the left side of the screen, the controls below it adjusted the video, and the supplementary course materials were displayed on the right side of the screen. The advantage of streaming video is that, like TV or radio, students receive the images and audio just before they see and hear them. This is much quicker than waiting for the entire video file to download before viewing it, as is the case with static images on the Web. The disadvantage is that in order to decrease file size and allow for a steady stream of data, the video must be compressed, shrinking the image from full size.

Lectures were typically available within 48 hours after they were presented on campus. Recorded lectures were available only to registered students; lectures were password protected after the second week of class.

Students downloaded and installed current versions of one of the supported video players before attempting to view the lectures. Students were responsible for ensuring that they had the necessary computer hardware and software, including course-specific software needed to complete course assignments. Harvard University did not provide equipment or software. No toll-free dial-in access was available.

Lecture notes were primarily in PowerPoint, allowing use of an automated time-stamp file as an aid in producing the video and in synchronizing the slides with the video. However, a manual time-keeper also recorded the timing of the slides, as other non-PowerPoint slides were also utilized.

Students living in the six-state New England area (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont) were required to take all classroom examinations on campus as scheduled. Distance education students outside the New England area arranged to take their exams off site and submitted a completed distance education proctored exam form to Academic Services at least two weeks in advance.

Distance students could submit homework via e-mail, fax, or postal mail through a centralized address at the Harvard Extension School.

3.3. OBJECTIVES

“Introduction to Biostatistics” was taught at the Harvard Extension School in each of the Fall 2004 and Spring 2005 semesters. The course was taught traditionally (without a distance option, e.g., without video) in Fall 2004. However, in Spring 2005, the course was offered with a distance option that included video access for all students in the course. Students could register for the course (hereafter termed registration status) as distance students, traditional students, or hybrid students (i.e., students that attend some live lectures of their choice in person but use the video for other lectures). Non-traditional students consisted of hybrid and distance students combined.

This research has several objectives:

1. To examine the effect on enrollment of adding a distance option to an Introduction to Biostatistics course.
2. To evaluate the “distance effect” by a comparison of grades of non-traditional students vs. traditional students in Spring 2005. The traditional students in this course provide a unique “internal” control group that can be utilized to evaluate the distance effect. Semester-to-semester variation is eliminated by the use of this internal control group.

3. To evaluate the "video effect" by a comparison of grades between traditional students in a course with a distance option that included access to lecture videos (Spring 2005) and traditional students in the same course offered without a distance option, and thus without video access (Fall 2004). Variation due to registration status is eliminated by using only traditional students in the control group.
4. To compare course evaluations for the two semesters. Because course evaluations are anonymous, the registration status of a responder cannot be determined. Thus evaluation of a distance effect, or a video effect, with respect to evaluations is not possible.

3.4. RESEARCH QUESTIONNAIRE AND SCHOOL SUPPORT

An "Information for Research Subjects and Research Questionnaire" was provided to students enrolled in each class. The questionnaire provided the students with a description of the study, information regarding confidentiality, potential risks and benefits, time commitment, and whom to contact with questions. The Information for Research Subjects and Research Questionnaire was reviewed and approved (judged exempt) by the Human Subjects Committee at the Harvard School of Public Health and by the Research Review Committee at Academic Services at the Harvard Extension School. As per the request of these committees, the instructor did not view the questionnaire until grades were finalized. A student signature was also required to include the student's grade in this evaluation. Students were treated equally regardless of their decision to participate.

The one-page Research Questionnaire collected data such as demographics, educational level, place of employment, whether the student had a prior statistics or biostatistics course, whether the student was a mathematics or statistics major, and whether the course was a requirement.

The Extension School provided funding for two Faculty Aides (i.e., students that required research experience in order to complete their program) to assist with this research project.

3.5. STATISTICAL CONSIDERATIONS AND METHODS

Descriptive statistics are used to describe the study sample. In general, categorical variables are summarized with counts and percentages. Continuous variables are summarized by displaying descriptive statistics (*n*, mean, standard deviation, and median). A bar graph is used to display student enrollment over time. Between-group comparisons are performed using Wilcoxon Rank Sum tests for continuous baseline variables and grades, Fisher's exact tests for categorical baseline variables, and the mean score test (Stokes, Davis, & Koch, 1995) was used to compare the evaluations. Confidence intervals (CIs) using the *t* distribution are used to estimate evaluation rating differences. Exact CIs are used to estimate between-group difference in grades.

All significance testing is performed at the 0.05 level and all reported p-values are two-sided. There is no adjustment for multiple testing, therefore results should be interpreted with caution.

4. RESULTS

4.1. ENROLLMENT

A substantial enrollment increase (100%) was noted when the distance option was offered. Figure 1 displays enrollment for the past six semesters (all taught by the same instructor) for this course. It is notable that this increase occurred without targeted advertising of the distance option. The course enrollment consisted of only 10% distance students but 39% hybrid students. This suggests that the freedom and flexibility of lecture or video availability offered by the hybrid option was particularly attractive to students.

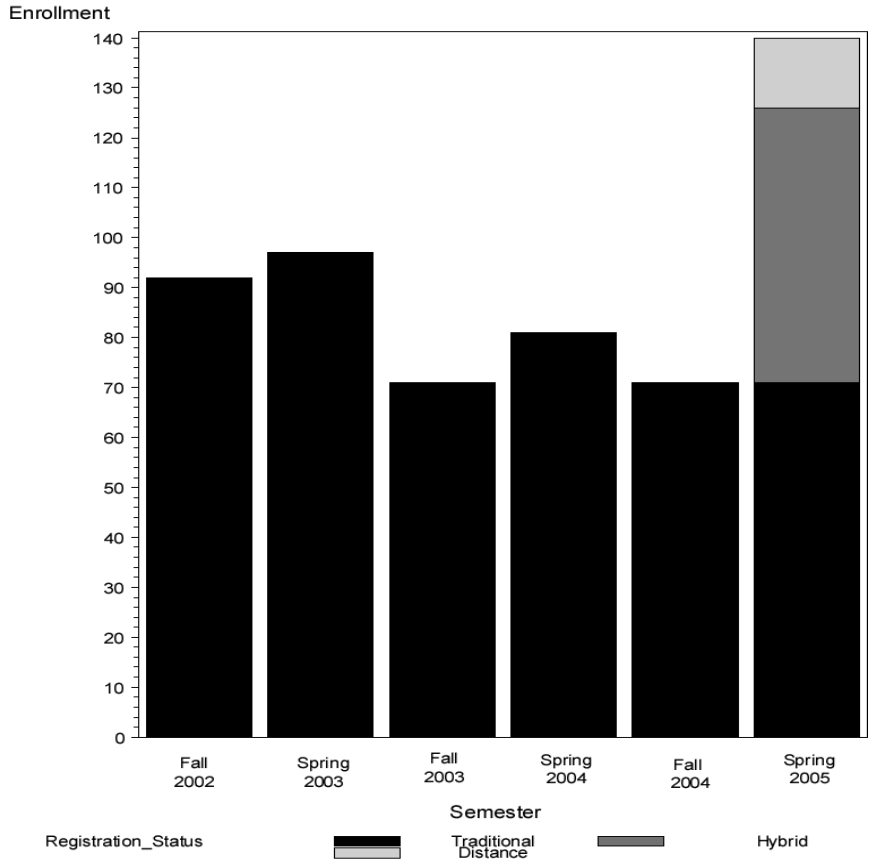

Figure 1. Student enrollment over time

4.2. DEMOGRAPHICS AND BASELINE CHARACTERISTICS

Table 1 displays demographic and baseline characteristics of students in the courses by semester. These data were collected via a questionnaire to assess similarity of the comparison groups at baseline (i.e., upon entering the course). Summaries are provided only for students who signed the Research Questionnaire. No significant differences between comparison groups are noted with respect to age, gender, race, education, and place of work. Further, the proportions of students that were graduate students, had a prior statistics course, were mathematics or statistics majors, and for which this was a required course were also not dissimilar.

Table 1. Summary of Student Demographics and Baseline Characteristics

Variable	Fall 2004 (*n*=52)	Spring 2005					
		Trad. (*n*=43)	Hybrid (*n*=28)	Distance (*n*=8)	Total (*n*=79)	p-value[a]	p-value[b]
Age (Mean/SD/Median)	31/9/28	29/8/26	29/7/27	35/10/39	30/8/26	.508	.283
Gender (*n*, %)						.468	.503
Male	17 (33%)	11 (26%)	9 (32%)	3 (37%)	23 (29%)		
Female	35 (67%)	32 (74%)	19 (68%)	5 (63%)	56 (71%)		
Race (*n*, %)						.490	.726
White	37 (71%)	34 (79%)	18 (64%)	6 (75%)	58 (73%)		
Black	1 (2%)	2 (5%)	2 (7%)	0 (0%)	4 (5%)		
Hispanic	3 (6%)	1 (2%)	0 (0%)	0 (0%)	1 (1%)		
Asian	10 (19%)	5 (12%)	6 (21%)	1 (13%)	12 (15%)		
Native American	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		
Other	1 (2%)	1 (2%)	2 (7%)	1 (13%)	4 (5%)		
Education[c] (*n*, %)							
Bachelor's	50 (96%)	37 (86%)	24 (86%)	6 (75%)	67 (85%)	.763	.135
Master's	11 (21%)	8 (19%)	5 (18%)	0 (0%)	13 (16%)	.762	.802
PhD	5 (10%)	1 (2%)	1 (4%)	1 (13%)	3 (4%)	.589	.217
MD	3 (6%)	1 (2%)	1 (4%)	1 (13%)	3 (4%)	.589	.624
Prior Stat Course	31 (60%)	24 (56%)	11 (39%)	5 (63%)	40 (51%)	.370	.835
Math/Stat Major	2 (4%)	1 (2%)	1 (4%)	0 (0%)	2 (3%)	>.995	>.995
Required Class	14 (17%)	16 (37%)	8 (29%)	3 (38%)	27 (34%)	.636	.376
Workplace (*n*, %)						.907	.303
Student	8 (15%)	3 (7%)	2 (7%)	1 (13%)	6 (8%)		
Academic	6 (12%)	7 (16%)	10 (36%)	0 (0%)	11 (22%)		
Hospital	10 (19%)	14 (33%)	6 (21%)	4 (50%)	24 (30%)		
Pharmaceutical	6 (12%)	1 (2%)	1 (4%)	0 (0%)	2 (3%)		
Biotechnology	8 (15%)	4 (9%)	3 (11%)	1 (13%)	8 (10%)		
Government	3 (6%)	2 (5%)	0 (0%)	1 (13%)	3 (4%)		
Other	11 (21%)	12 (30%)	6 (21%)	1 (13%)	19 (24%)		
Credit Level (*n*, %)						>.995	.538
Graduate	25 (48%)	24 (56%)	17 (61%)	4 (50%)	45 (57%)		
Undergraduate	27 (52%)	19 (44%)	11 (39%)	4 (50%)	34 (43%)		

[a]Traditional students vs. non-traditional students in Spring 2005. [b]Traditional students in Spring 2005 vs. traditional students in Fall 2004. [c]Responses are not mutually exclusive.

Table 2. Summary of Student Grades (Spring 2005 Traditional vs. Non-Traditional)

Variable (Mean/SD/Median)	Total	Traditional	Hybrid	Distance	p-value[a]	Difference (95% CI)[b]	Difference (95% CI)[c]	Difference (95% CI)[d]
Total (*n*)	79	43	28	8				
Overall grade	88/11/91	89/12/91	89/9/91	85/13/87	0.82	(-4.2, 5.3)	(-13.3, 6.3)	(-4.5, 5.4)
Exam average	82/14/85	82/15/83	83/12/85	78/19/83	0.83	(-5.0, 7.5)	(-17.5, 7.5)	(-7.5, 7.5)
Homework average	92/8/94	92/8/95	93/7/95	91/5/93	0.66	(-1.7, 2.5)	(-5.5, 2.3)	(-2.3, 2.3)
Project average	94/7/96[e]	94/7/97[f]	94/7/96[g]	89/8/89[h]	0.47	(-1.5, 4.0)	(-14.5, 1.5)	(-3.5, 2.0)

[a]Wilcoxon rank sum test comparing Spring 2005 traditional vs. non-traditional students (hybrid and distance combined), stratified by credit level.
[b]Exact CI for Spring 2005 traditional vs. non-traditional students.
[c]Exact CI for Spring 2005 traditional vs. distance students.
[d]Exact CI for Spring 2005 traditional vs. hybrid students (Hodges & Lehmann, 1963; Lehmann, 1975).
[e]$n = 45$. [f]$n = 24$. [g]$n = 17$. [8]$n = 4$.

4.3. GRADES

Evaluation of the Distance Effect We compared the grades (overall course average, exam average, and homework average) of the traditional students to the non-traditional students in Spring 2005 in order to evaluate the distance effect, stratifying by credit level (graduate or undergraduate). The independent variable was registration status, and the dependent variable was grade. Results are displayed in Table 2.

No statistically significant differences between traditional versus non-traditional students (Spring 2005) were noted with respect to overall course average, exam average (i.e., equally weighted average of the midterm and final exams), homework average, or project average. CI estimates (95%) for the difference between traditional and non-traditional students indicate that group differences for the overall median grade may be as large as 5 points in either direction.

Evaluation of the Video Effect We further compared the traditional students in Spring 2005 to the traditional students from Fall 2004 to evaluate the video effect, stratifying by credit level (graduate or undergraduate). The independent variable was semester and the dependent variable was grade. Table 3 displays the results.

Statistically significant differences with respect to exam average were noted between traditional students in Spring 2005 and Fall 2004, with the students in Spring 2005 performing worse. Confidence interval estimates indicate that median group differences for the overall grade may be as large 12.5 points. This is believed to be caused by (unintentional) semester-to-semester variation in exam difficulty. However, one cannot rule out a detrimental effect of the distance option on traditional students. No statistically significant differences were noted with respect to overall course average, homework average, or project average.

Table 3. Summary of Student Grades (Fall 2004 Traditional vs. Spring 2005 Traditional)

Variable (Mean/SD/Median)	Fall 2004 Total	Spring 2005 Traditional	p-value[a]	Difference (95% CI)[b]
Total (*n*)	52	43		
Overall grade	92/10/95	89/12/91	0.11	(-7.6, 0.8)
Exam average	91/11/95	82/15/83	<0.01	(-12.5, -2.5)
Homework average	90/10/94	92/8/95	0.51	(-1.3, 2.7)
Project average	92/6/93[c]	94/7/97[d]	0..08	(0.0, 6.0)

[a]Wilcoxon rank sum test comparing Fall 2004 vs. Spring 2005 traditional students, stratified by credit level.
[b]Exact CI for Fall 2004 vs. Spring 2005 traditional students (Hodges & Lehmann, 1963; Lehmann, 1975).
[c]n=25. [d]n=24.

4.4. COURSE EVALUATIONS

Course evaluations were voluntary, anonymous, and were not reviewed by the instructor until grades had been finalized and submitted. Thus, we were unable to distinguish evaluations by registration status. However, we compared the evaluations from Spring 2005 to the evaluations from Fall 2004 to examine if the addition of the distance option affects course evaluations. In particular, we compared responses to “rate

the course overall" and "rate the instructor overall." Each was rated on a scale from 1 (poor) to 5 (very good). The dependent variables were evaluation scores for the course and the instructor, and the independent variable was semester. Results are displayed in Table 4. No significant differences between semesters were noted with respect to the overall course rating or the overall instructor rating. The CIs for the mean difference of the evaluations between semesters (Spring 2005 minus Fall 2004) provide ranges of potential differences between evaluations for the overall course and the overall instructor ratings.

Table 4. Course Evaluation Summary

Overall Rating	Fall 2004	Spring 2005	p-value[a]	95% CI[b]
Course				
n	50	58		
Mean	3.94	4.09		(-0.18, 0.47)
S.D.	0.87	0.82		
Response *n*(%)			.37	
1	1 (2%)	1 (2%)		
2	2 (4%)	1 (2%)		
3	8 (16%)	8 (14%)		
4	27 (54%)	30 (51%)		
5	12 (24%)	18 (31%)		
Instructor				
n	47	57		
Mean	4.02	4.25		(-0.09, 0.54)
S.D.	0.94	0.66		
Response *n*(%)			.16	
1	1 (2%)	0 (0%)		
2	1 (2%)	0 (0%)		
3	11 (24%)	7 (12%)		
4	17 (36%)	29 (51%)		
5	17 (36%)	21 (37%)		

[a]Mean score test (Stokes, Davis, & Koch, 1995).
[b]Normal approximation (Spring 2005 minus Fall 2004).

4.5. OTHER OBSERVATIONS

Several other observations regarding the distance version of the course are worth noting, including organizational, instructor, and student issues.

Organizational Issues Purchasing the course text and appropriate software for the course was more difficult for distance students as they did not have access to the campus book store. We identified websites (e.g., software company websites) from which students could purchase the necessary materials, and provided links to these websites from the course website.

Students had different computing platforms, as well as different versions of software. Documents posted on the course website contained special characters/symbols (e.g., statistical notation such as Greek letters, etc.). Some students had difficulty with their software correctly recognizing statistical notation due to the different software versions. Creating pdf files alleviated the problem; however, students still had to download appropriate fonts to view the lecture notes.

Instructor Issues There was a substantial increase in the volume of e-mail for the instructor and the teaching assistants. This increase could be due in part to the increase in enrollment, but may also be due to the fact that e-mail is the only method of communication for the distance students or that iterative communication between students and instructors/TAs is necessary for biostatistics courses. Homework submissions via e-mail can also get blocked by spam filters.

In traditional courses, homework is submitted in class by all students, and thus an instructor has all student homework organized into a single location. However, with the distance education option, there was an increase in the proportion of homework assignments that were submitted by fax and e-mail, making it more difficult to keep track of submitted homework. This may be more of an issue in courses such as biostatistics, when frequent homework assignments are part of the course structure and it is necessary to regularly provide feedback to students.

The instructor learned to avoid phrases such as “over here” when using a laser pointer during lectures, as distance students were not able to view where the instructor was pointing. Instead, the instructor used phrases such as “in the upper right-hand corner.” This can be potentially problematic with graphs, figures, and other non-text slides often used in biostatistics courses to illustrate concepts and visualize analyses.

Student Issues Homework was returned to distance students using postal mail, and thus could take a couple of weeks to reach distance students that lived outside of the United States. A few distance students noted that this was a significant disadvantage.

Distance students cannot attend help sessions. Although access to the instructor and all of the TAs was available during the course, some distance students believed that not being able to attend help sessions was a significant disadvantage. This can be potentially problematic when students have to learn how to use statistical software.

Some students noted that something was lost when watching the video versus the live lecture, comparing it to watching a concert live versus watching it on television.

A few semi-local students stated that the availability of the video provided time to study that would otherwise be spent commuting. Notably, commuting to live lectures for our course involves commuting and parking in a congested area (Harvard Square in Cambridge, Massachusetts, USA).

5. DISCUSSION

In this study, we observed an increase in enrollment in an “Introduction to Biostatistics” course offered with a distance option. Notably, enrollment doubled from the previous semester, with the “hybrid” option appearing particularly attractive to students. We failed to identify a significant distance effect with regard to student grades. We found a statistically significant video effect with respect to exam grades: Traditional students in a course that offered a distance option performed worse than traditional students in a purely traditional course. However, we believe that these differences in grades are likely due to unintentional semester-to-semester variability in exam difficulty, but cannot rule out a potential detrimental effect of the distance option on traditional students. We note, however, that no differences between overall grade point averages were detected. No evaluation differences were noted between the semesters that offered a distance option compared to the semester that offered the course only traditionally.

We acknowledge possible limitations of this study due to several potential sources of bias. Because this is a non-randomized study, it is possible that comparison groups were different at baseline (selection bias). Our data do not rule out the possibility that either

(1) non-traditional students are superior students but distance delivery is inferior, or (2) non-traditional students are inferior students but distance delivery is superior. The "distance effect" is not solely the distance delivery effect, but is actually a combination of this effect and differences between traditional and non-traditional students. If there are differences between traditional and non-traditional students, then it is difficult to estimate one important parameter of interest: the difference between how a student would perform in the course from a distance versus how the student would perform in the course if they took the course traditionally. In an attempt to identify dissimilarities between traditional and non-traditional students, we collected "baseline" data using the questionnaire and failed to find significant differences between comparison groups for some important variables. However, group differences may exist with respect to other important characteristics that we were not able to identify or measure. Many distance students do not have the option to take the course traditionally due to geographic or time constraints, and for these students, the important question is whether they can successfully complete the course. It is also possible that our reference group (i.e., traditional students) is not representative of all traditional students. We are able to study only the students that happen to enroll into our course. We also note that the semester-to-semester variability in exams and assignments, and the tendency for an instructor to revise his or her teaching methods over time, could affect the between semester comparisons. Furthermore, because we were able to use data only from students that signed the Research Questionnaire (52/71, 73%, in Fall 2004 and 79/140, 56%, in Spring 2005), it is possible that a volunteer bias could affect group comparisons of baseline data. Another limitation is that we do not have data regarding classroom attendance. Lastly, it is important to note the possibility of informative drop-out. For example, if all students that perform poorly early in the course drop out, leaving only the students that perform well (and this drop-out is more prevalent in one comparison group than another), then group comparisons would be biased. However, we have no data to conduct such an evaluation.

We further stress that our results should not be generalized broadly due to the differences in distance methods of delivery. More studies will be needed to investigate whether our results may be generally applicable to "Introduction to Biostatistics" courses with asynchronous video as an option, or if these results apply only to our university. Our study is not definitive, but it is a first step in providing valuable information that can be used as a basis for future research.

Based on our experience, we offer the following recommendations and comments for instructors of distance courses:

1. Instructors may wish to consider themselves students of the distance education process, and attempt to search for ways to understand the unique method of delivery and communication, and how it affects student learning. Attempt to identify ways to help students learn under this system. Learning statistical software can be particularly difficult for students without timely feedback.
2. Provide avenues of communication, such as e-mail, for which relatively timely responses can be delivered. For example, if you have very experienced TAs (as in this course), then assign specific TAs to communicate with distance students via e-mail. This approach should be pursued cautiously, as more instructor control and oversight will likely be required with inexperienced TAs. Whether e-mail is directed by the instructor or TAs, it is important to regularly respond to e-mail. Several web-based course management tools, such as WebCT and Blackboard, can be helpful as bulletin boards. Chat rooms, wikis, and blogs can also allow and facilitate

class discussions. Additionally, on-line testing and students' performance feedback can be done with the use of these tools.

3. Create a comprehensive website that provides timely course materials and answers to common questions using software tools, such as WebCT or Blackboard. Providing handouts for statistical software is helpful for students. This will help to reduce the number of student questions.
4. Make sure that there is adequate school support, including appropriate technology with high quality sound and video, as well as support for distributing homework and for arranging of proctored exams.
5. Be prepared for more work. Allow more time for preparation and interaction with distance students. (It is thus appropriate for the instructors and TAs to be appropriately compensated. The Harvard Extension School increases compensation for distance education courses.)
6. Learn to be flexible and adaptable to distance student needs. Create a balanced approach of understanding the potential difficulties for distance students, and maintaining academic integrity, by requiring students to be responsible with assignments and exams.
7. Discuss the ownership and future use of videotapes with the school. Legality questions may arise regarding the future use of such videotapes.

Distance education remains a controversial topic. However, distance education is here to stay for the foreseeable future. More extensive evaluations of the effectiveness of distance learning through comparisons of distance versus traditional students using internal control groups are needed. Such evaluations may be difficult as the distinction between online and traditional courses begins to blur; many traditional courses are also beginning to incorporate more online components such as message boards, chat rooms, and the electronic filing of homework. Evaluations of other biostatistics/statistics courses, and other methods of delivery, are also needed. Methods to enhance student learning in such courses should be researched. Instructors should realize that they are also students and, therefore, need to learn how to teach in the realm of distance education.

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SCOTT R. EVANS
FXB 513
Department for Biostatistics
Harvard School of Public Health
651 Huntington Ave
Boston, MA 02115