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Assessing Virtual Students' Quiz Performance in Web-Mediated Synchronous Instruction

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Abstract
Differences in teaching presence between virtual and traditional venues for a synchronous public budgeting class are examined by comparing the results of lecture-based quizzes. Previous studies, usually based on surveys, have focused on multiple aspects of virtual learners' experiences through the community of inquiry model. This research emphasizes virtual learners' ability to absorb lectures through web-mediated broadcasts, hosted via a commercial product. Statistical analysis indicated slightly poorer performance by virtual attendees, but with the impact limited narrowly to certain lecture topics. Ancillary uses of the broadcasts are also described, including enhancement of an asynchronous online budgeting class using recorded lectures.

KEY WORDS: teaching presence; synchronous distance education; videoconferencing; transactional distance; webinar

Introduction

The absence of significant differences found in student perception of and performance in online and face-to-face modes of instruction (Daymont & Blau, 2008) has puzzled those teachers who feel that something of the traditional classroom experience must be lost when mediated through the Internet. Under Moore's (1993) concept of "transactional distance," crucial factors separating instructor and student account for the engagement or disengagement of students. To surmount distance in the learning process the community of inquiry (CoI) framework (Garrison et al., 2000; Garrison & Archer, 2007) defines three categories of presence—social, cognitive, and teaching—to engage students.

Predominant application of this framework in studies of asynchronous online courses invites the exploration of CoI in a synchronous format. Garrison and Arbaugh (2007) note that "the increased ease with which media such as audio and video can be introduced into virtual learning environments may have significant implications for the structure, development, and interaction of the three presences" (p. 168). While technological advancement may encourage the type of course studied here by rectifying "limits on the technology current in academia," there remains the potential obstacle of educators feeling "that synchronous communication compromises the convenience and/or flexibility of asynchronous formats" (Arbaugh & Stelzer, 2003, p. 19). This research may help shed additional light on those concerns.

Aside from introduction of desktop videoconferencing technology, the public budgeting course at the heart of this research functioned very traditionally in most respects: modest-sized classes composed of degree-seeking students taught through predominantly lecture-based instruction. Voluntary attendance through web-mediated, synchronous broadcast of classes represented the only concession to the Internet age. But the commercial availability of affordable broadcasting technology (Furr & Ragsdale, 2002) suggests broader application in the

future for classes as traditional in other respects as this one. The possibility of reusing recorded broadcasts for a parallel (asynchronous) online section of public budgeting was another inducement for launching the grant-based project, though the results of the online course are secondary here. The key rationale for this research is the narrow focus on teaching presence, in particular the *direct instruction* component.

The rationale for this study is based on the recent cost-effectiveness of technologies such as web-based broadcasting, which lower the barriers to reaching virtual attendees synchronously. At the same time, unabated proliferation of online education, involving more than 6 million students, which exceeds 30 percent of the total enrollment in postsecondary, degree-granting institutions, as reflected in biennial national surveys (Allen & Seaman, 2011, p. 11), creates new demand for web-based instruction. One possibility for meeting this demand could be virtual availability of largely traditional courses, such as the subject of this study. In that case better understanding of the promise and potential drawbacks of such offerings can contribute to more intelligent use of this technology.

Literature Review

Research into transactional distance (Moore, 1993) and the closely allied literature on transactional presence (Naylor & Wilson, 2009; Shin, 2002, 2003) have identified the challenges of extending instructor-student and peer relationships found in highly functional traditional classrooms to online students. Yet many elements of instruction, including structure, materials, accessibility, student participation, peer connectedness, autonomous reflection, and other factors that influence the effectiveness of both online and traditional classes tend to engage or disengage distance students, just as they do face-to-face students. Mirroring this multifaceted learning process, the integrated nature of the CoI framework (Garrison et al., 2000; Garrison & Archer, 2007), poses a particular challenge in focusing on a single element. Nevertheless, this research seeks to zero in on the teaching presence category, largely focused on direct instruction. This emphasis on the ability to communicate the classroom experience to virtual students attending synchronously tests the premise that some aspects of direct instruction may be less effective for students who access audiovisual content at scattered locations through a less robust medium (the Internet) than dedicated videoconferencing networks or interactive television.

This research aligns most closely with studies of differences in achievement between students in online versus traditional formats (Arbaugh & Stelzer, 2003; Daymont & Blau, 2008; Friday et al., 2006; Hiltz et al., 2000; Summers et. al., 2005). The key distinction here is the seemingly minimal difference between the content available to virtual and in-person students. The question of how well educational content is conveyed by an audio-visual medium, initially television (Schramm, 1962), has been largely resolved, with prevalent findings of no significant difference between face-to-face and remote students' performance (Saba, 2000; Arbaugh & Stelzer, 2003). Yet research into virtual students' learning process under a synchronous format is needed, particularly in view of scant interest in this format revealed in a study of management education (Stelzer et al., 2002). When research has explored learning in a synchronous format, the prevalent technologies have been dedicated (as opposed to web-based) videoconferencing and interactive television (Skopek & Schuhmann, 2008), which benefit from fixed, extensively supported infrastructure and may yield different experiences as compared with experimental conditions accompanying trials of an emerging web-based technology.

Previous studies have focused on diffuse aspects of virtual learners' engagement in their education (Marks & al., 2005). Research examining CoI's social presence dimension of students' involvement in the learning process usually has been survey-based (see, for example, Williams et al., 2006). It has established meaningful interaction as a prerequisite for other dimensions fully functioning and assigned that responsibility to instructors (Swan & Shea, 2005). Recognizing the essential nature of social presence, this research nonetheless deemphasizes that dimension of the CoI framework by focusing on the instructor's role in directly conveying the knowledge that students need to absorb. Even the higher-order integration of concepts, an emphasis of CoI's cognitive presence dimension, is less central to this research because of the quite straightforward nature of the knowledge conveyed. Although greater integration of CoI dimensions is sought (Garrison & Arbaugh, 2007) and is admittedly crucial, this research represents a limited rather than a broad inquiry into the resilience of teaching presence through the web-mediated broadcast.

The particular focus on teaching presence separates this inquiry from previous studies based on a synchronous format, which examined students' performance in multiple dimensions (Clouse & Evans, 2003) or looked broadly at issues of satisfaction, accomplishment (self-reported), and accessibility (Skopek & Schuhmann, 2007). Such broad-gauge research encompasses many elements of learning-based models and involves cross-cutting influences. In contrast, the structure of this course, described in detail below, served to segment the information that was conveyed primarily through lectures, which was the basis for the assessment of student performance. In this way learning that relied on direct instruction could be separately evaluated, apart from the more integrated (and more crucial, from a pedagogical standpoint) learning that occurred in the applied portion of the course, which constituted its core.

Methodology

The public budgeting course I taught scarcely could be called a hybrid offering, since students could choose, as a sizeable minority did, to attend the class entirely in person. (But the recording of broadcast lectures did make possible the hybridization of an online public budgeting section taught in parallel, as addressed in the penultimate section.) Another unconventional aspect of this design was the lack of a requirement to select a mode of attendance. Students could attend virtually in one class and in person the next, which meant that the virtual and in-person groups were constituted differently from week to week. This mingling of the categories dampened some of the differences that have characterized virtual students in previous research. Departing from the traditional classroom experience minimally—only in providing the option of a web-based medium—served to narrow the factors under consideration. Limiting the outcome of interest to students' achievement on lecture-based quizzes further restricted the inquiry.

Students physically located at home, at work, in libraries, or at other access points, rather than collocated with other students—as is the case for satellite sites linked by dedicated networks, confront different challenges in absorbing traditionally delivered lecture material. For example, virtual students may be subject to distractions far beyond those posed by the classroom. Mechanisms bundled with the software, such as polling, provide the capacity to assess the presence and engagement of virtual attendees, but these would require a greater investment in mastering the technology than this trial required. Indeed, impact on the instructor was kept to a minimum, consistent with the modest level of investments in infrastructure and software. Rather than suggesting this course as a model for distance education, the introduction of web-based broadcasting here tested the feasibility of an affordable, portable configuration for a modestly

technically proficient instructor and students who place a high value on convenient access, a crucial motivation for choosing distance education (for example, see Wyatt, 2005).

The single-course research design requires justification, since this design has been deemphasized during the last 15 years of distance education studies in favor of multi-course studies (Arbaugh et al., 2010, p. 46). The author's public budgeting course had attributes, addressed below, that lent itself to an emphasis on teaching presence. Expansion of the study to include other instructors, however, would have contributed to more generalizable findings. The primary reason for an exclusive focus on my course was that the software solution was unavailable to others, because the specially licensed platform was external to the university's instructional technology plant and available initially through an individual instructor license. The cost of this software and accompanying service was funded by a one-time grant.[1]

The stand-alone technology platform was integral to the research, as well as to the hardware/software trial, which was the genesis for the research. The idea of evaluating a modestly priced web-based broadcasting solution, which was viable for a small number of instructors, even a single instructor, is consistent with the diffusion of innovation theory (Rogers, 2003), which suggests that early adopters usually lead general adoption of new technology by a significant interval: the "S-shaped" pattern of adoption (p. 275). Relatively few universities have the resources to provide universal web-conferencing infrastructure. Even for universities where such an investment is possible, much of the infrastructure could be expected to be wasted initially, given the necessity to build critical mass before the technology can achieve widespread acceptance.

Another crucial reason for integrating web-based broadcasting into this traditional public budgeting course was the dissemination of recorded lectures to students in an online section of the same class. Although the resultant blending of face-to-face and online instruction is not the main focus of this research, the goal of going beyond a text-based format for the online section was an important rationale for experimenting with the webinar technology. Informal feedback on the utility of recorded lectures is provided below, following the quantitative results.

Technical Solution

The core component of the technical solution was the proprietary software and service obtained from Elluminate (currently Blackboard Collaborate) that provided "webinar" capability.

The other elements, which constituted a portable hardware solution (installed prior to each class), did not add to the cost of the project: either being owned by the instructor or furnished by the University's Office of Technology Support. Even the most elaborate hardware configuration used for this research could have been purchased for approximately $2,000. Software consisted largely of Microsoft Office products, such as PowerPoint, used to populate the "whiteboard" images—displayed for virtual and in-person attendees—around which lectures were organized. Microsoft Excel underlay the computations and analysis for the applied financial assignments, but seldom was employed in the salient portion of the lectures, which dealt with contextual and political issues. Table 1 shows how the hardware used with Elluminate evolved. The progression to successively more complex configurations over three semesters, before reducing the hardware to a web camera and wireless keyboard/mouse for the last semester, represented a largely unsuccessful attempt to capture class discussion in a manner audible to virtual attendees.

Table 1.
Technical Solution by Semester

Semester	Hardware Configuration	Webinar Software/Service
1st	Classroom computer; wireless microphone; web camera; wireless mouse tablet	Elluminate Live, Version 9
2nd	Classroom computer; wireless microphone; web camera; second computer; wireless mouse and keyboard	Elluminate Live, Version 9
3rd	Same as second semester (above)	Elluminate Live, Version 10
4th	Web camera; wireless mouse and keyboard	Elluminate Live, Version 10

Despite the different hardware configurations, it was seldom possible for virtual attendees to fully hear questions and exchanges by other students. Due to the difficulties of managing multiple speakers through Elluminate and network limitations, virtual attendees "chatted" rather than spoke their questions and comments, so their input was always visible. The instructor was generally audible, barring network issues. But students' questions could only be heard clearly outside the classroom to the extent they spoke up considerably and were located in reasonable proximity to the microphone, roughly the front half of the class. Early on, one tactic to broadcast classroom discussion was for the instructor (wearing a microphone during that phase of the trial) to move physically closer to the speakers when extended discussion occurred. But most of the students very briefly requested clarifications or examples from the instructor or gave relatively short answers to the instructors' questions, which did not allow enough time to approach them.

An unintended consequence of the changing hardware configurations was the added complexity and the associated risk of failures. Table 2 lists the most common technical issues, illustrating the degree to which the instructor, as technician, had to be involved with minimizing problems with the infrastructure. The simplest configuration was ultimately chosen (in the fourth semester), using the stationary microphone capability of the web camera, which featured zone-oriented audio pickup. This solution effectively covered the front half of the room, with minimal impact on hearing the instructor and enhanced capacity to make out some of the comments and questions from students whose voices projected. This configuration's reliability and ease of weekly setup and management during class represented the most workable solution, as well as the most affordable (had the equipment not already been purchased). Nevertheless, performance tradeoffs included brief inaudible intervals and the unconventional camera angle, which faced the students rather than the instructor.

Table 2.
Selected Technical Challenges Encountered Using Elluminate with Minimal Support

Issue Type	Frequency	Problem Detection	Solution Description
Network interruption	Multiple times per class, at interval of one to two hours	Message says "attempting to reconnect."	If automatically (usual case) reconnected, take no action. In case of "reconnect failed" message, close virtual classroom window. Then, go to Elluminate start window in browser and reload.
Audio/video interruption	Approximately half of classes	After network interruption, "chat" panel in the virtual classroom window says "Left at [time]" then "Joined at [time]."	Activate "talk" button to resume audio transmission. Select "stop" button for video transmission, then activate "video" button to resume transmission.
Microphone interruption	Approximately half of classes	Message says "fatal error" and "audio input failed"; watch for "stop sign" icon.	Switch audio input to alternate source; then switch back. Activate "talk" button again to resume audio transmission.
Second computer failure	Once-twice per semester	Eluminate screen frozen—slides not advancing; volume "bars" on audio not moving.	Switch to primary computer, using stationary, hard-wired microphone. Conduct virtual class without video.

The issues listed in Table 2 do not exhaust the problems encountered using Elluminate. Others, primarily classifiable as operator errors, such as not initiating the recording feature or forgetting to activate the "talk" button, were usually rectified quickly, once alert students or the instructor noticed the omission. This should not be interpreted as a negative assessment of the Elluminate product or other elements of the technical solution. The crucial point is that technical issues are almost an inevitable byproduct of non-production installations, with the accompanying absence of dedicated technical support, and must be anticipated. Instructor time and attention siphoned away from pedagogy by technical problems that arose and the workarounds they necessitated (including non-technical responses, such as repeating material for virtual students who missed it due to interruptions) set up a tradeoff, to be weighed against the convenience for students of extending education beyond classroom walls.

Course Design

Another facet of the research design was the control of instructor-related variables that can bedevil multi-course studies. Whereas limiting the study to a single instructor made the research more idiosyncratic, a compensating advantage was to control for varying instructional techniques. A final justification for selection of this instructor/course combination for studying web-broadcasting technology is the relative ease with which the experimental design could be adapted to this course. The public budgeting course had been designed, prior to the infusion of technology, to address two largely disjoint themes. This bifurcation was an artifact of instructor choice, as well as the practical focus of the curriculum. But the resulting division of context from application, as an organizing principle of the course, was the basis for the statistical test of the contextual topics alone—virtually entirely dependent upon lecture and class discussion.

The University's strong practitioner emphasis, as manifested in the Master of Public Administration (MPA) degree, meant downplaying the political and contextual dimensions of public budgeting. As a result this course's emphasis was split quite unevenly between budgetary application at the core and context and politics on the margins. Since the former counted for the greater proportion of the grade by far, students had a strong incentive to be engaged during the second half of each 150-minute class, when the applied financial assignments were explained and related examples worked. The first half of these classes, when budgetary context and politics were discussed, held intrinsic interest for a number of the students (and the instructor), but provided scant extrinsic motivation for engagement. Accordingly, a lecture-based quiz on one or two of the main points covered in the first half of the class was always given at the halfway point. The weekly quiz, which did not involve assigned reading beyond the lecture material, was incorporated into the original course design, preceding the virtual attendance option. Table 3 illustrates the difference between contextual and political topics covered in the first half of each class versus the applied topics in the latter half.

Table 3.
Contextual and Political Topics versus Applied Topics in Public Budgeting Course

Module	Contextual/Political Topic Examples	Applied Topic Examples
Budgetary context	Theoretical and political distinctions between public and private goods	Distribution of state & local revenue sources and spending allocations
Budget structure	Line-item, programmatic, and performance-based budgeting paradigms	Limits of fund accounting and line-item budgeting in cutback scenarios
Budget preparation and execution	Incremental, rational budgetary theories; budget projection and analysis methods	Multi-year patterns in budgetary baseline and variance analyses
Capital budgeting	Time value of money, present value, and their implications for capital budgets	Cost-benefit analysis
Revenue sources	Taxation equity, incidence, and efficacy	State multi-year revenue analysis

Quiz grades constituted an extra-credit rather than averaged-in portion of the overall grade, with the preponderance of grades in the course based on the applied financial assignments, which emphasized computing, reasoning, and writing proficiency. Quiz grades served to "upgrade" the results of financial assignments, with the effect that virtually all students who maintained at least "B" grades on all financial assignments earned "A" grades in the course. Students who received grades of at least "A-" on all financial assignments also earned "A" grades in the course; for them quiz grades were irrelevant. Only students who attended received quizzes: handed out in class and, nearly simultaneously, emailed to virtual attendees. Quiz distribution was timed to coincide with a 15-minute break, roughly halfway through the class period lasting two and one-half hours. Fifteen minutes was considered ample time to answer one or two questions, usually multiple choice. An "open-book, open-web" policy and relatively easy questions—a large majority of students answered both correctly for "A" grades—contributed to the low-stakes testing regime and discouraged cheating: effectively limited to the sharing of answers, and yielding little prospect of gain. These details do not serve to exemplify or justify an unorthodox grading policy, but to emphasize that the quiz was a relatively minor attendance-enforcing device, gauging students' general grasp of the lecture material and related discussion.

Data

Within the four semesters, the middle portion of the course served as the sample, omitting the initial three and last three classes in a 14-week semester. The rationale for leaving out quizzes administered during the initial classes was that explaining the option for web-based attendance, covering the logistics of attending remotely, and assembling a reasonable number (three or more) of virtual attendees generally occupied the first three classes. Delaying measurement also allowed for the learning curves of both attending virtually and taking quizzes. The rationale for omitting classes late in the semester is an artifact of the grading policy, which mandated attendance of 10 classes. After the required 10 attendances, completed quizzes were assigned grades of "A" automatically. Another atypical facet of end-of-semester classes was the scheduling of guest lectures, when no quizzes were administered.

A total of 88 students participated in the four sections of the public budgeting course, accounting for 567 total attendances. One important difference with previous research is that the groups of students attending face-to-face and attending virtually are not discrete. Approximately half the students attended in both modes, with most of those choosing a single mode opting for face-to-face attendance (36 percent of all students), versus 14 percent selecting entirely virtual attendance. For the 50 percent of the class attending both virtually and face-to-face, the median number of virtual attendances was three (3) and the mean was 3.8.

The implication of these patterns of attendance is that the populations of virtual and face-to-face attendees were intermingled substantially. Dual-mode attendees accounted for 42 percent of the quizzes administered in person and 64 percent of the virtual quizzes. The mixing of these populations tended to dampen effects reflecting the characteristics of early-adopting students, since deliberate and even cautious adopters were also included among the virtual attendees. The in-person attendances, with the majority (58 percent) being attributable to solely in-person attendees, were potentially more representative of late-adopting attributes. But other reasons could contribute to exclusively in-person attendance, such as the scheduling of other on-campus activities in proximity to the budgeting class (including consecutive classes, quite common since MPA classes were offered primarily in the evenings).

Dependent Variable

Quiz grades serve as the dependent variable, normalized for relative performance using ordinal values. Students earning the highest grade on a particular quiz, always an "A," were assigned a value of four (4). The next-highest grade, which varied from "B" to "A-," resulted in an assigned value of three (3), and so forth to the lowest grades, which resulted in assigned values ranging from two (2) to zero (0): with none of the quizzes producing more than five grade levels. Normalizing the grading distribution preserved the order of student performance, which more closely tracked the phenomenon of interest. Selection of a categorical dependent variable necessitated use of ordinal logistic regression, as opposed to multiple regression, which assumes a normal distribution for the dependent variable.

Quizzes usually included two questions, composed of true-false or multiple choice types, sometimes requiring a brief explanation to support the student's selection. Quizzes were intended to be confirmatory, reinforcing points emphasized during lectures, rather than challenging students to integrate concepts. Accordingly, the distribution of quiz grades was skewed toward the highest grade, with nearly 70 percent of quizzes graded "A."

Independent Variables

Three sources of independent variables were employed to explain students' performance on lecture-based quizzes. One explanatory variable, based on students' ability, has been used often in research on the effectiveness of online instruction. For this research measurement of ability was provided by the grade point average (GPA) on applied financial assignments, which were the primary contributors to the overall course grade. Recall that quiz performance was used as an extra-credit component of the overall grade, which tended to help students with poor to good performance on the financial assignments, but not excellent performers. Applied financial assignments drew upon a general knowledge base, since the emphasis in grading these was on computing, reasoning, and writing proficiency, rather than the contextual and political aspects of budgeting, which were the basis for quizzes. Given the largely disjoint bodies of knowledge for these two components of the overall grade, sufficient independence was maintained and multi-collinearity avoided, so that the common element that applied to both the financial assignments and the quizzes was students' basic scholastic acumen.

Another factor that applied to this use of broadcasting technology is the attendance mode, in-person or virtual. This variable supported an examination of virtual students' absorption of lecture material on budgetary politics and context, as compared to students attending in person. Because of the synchronous broadcast, the previously identified advantages of distance education, such as time for reflection, did not apply in this instance. Neither group of students had an advantage in resources, since the course was scheduled for a laboratory classroom, providing in-person students with computers. The laboratory was assigned because of extensive use of Excel for the applied financial assignments. Internet access was permitted in completing quizzes.

In the absence of additional time or resources available to virtual students, the salient mechanisms appear to be the transmission capacity—to broadcast the lecture content faithfully—and the comparative levels of distraction inside and outside the classroom setting. In both cases the effects can be expected to reduce virtual student performance. The standard for effectiveness of transmission is to provide an equivalent experience to in-person attendance. The sources of subpar transmission included component limitations, for example the inability of virtual students to hear clearly the questions posed by students in class; operator error, such as the instructor's failure to turn on the microphone; and a multitude of possible hardware or software failures, such as the interruption of the signal between the classroom computer and the network (see Table 2). The only plausible elements of a superior experience from transmission would involve aids such as closed captioning, which were not provided in this case. With regard to potential distractions, the instructor exercised a large degree of control over the classroom environment, but lacked comparable control over the virtual environment—accordingly presumed to vary considerably.

The remaining factors revolved around the issue of experience. Two of the independent variables involved the experience with quizzes: one with the sequence of the quiz within the semester (first through eighth); and the other with the number of virtual quizzes taken previously. Both of these variables could be expected to contribute to student performance, by increasing students' familiarity with the quiz format in the former case, and increasing students'

facility with the virtual environment in the latter case. The final variable measured the instructor's experience with the technology, which could be expected to increase with use of the webinar service in each successive semester. Such learning might have been enhanced by reliance on a stable hardware configuration, but, as review of Table 1 shows, the technical solution was in flux, although use of Elluminate as the webinar service was a constant throughout the trial period.

Results

The statistical evidence of the model was provided through an ordered logistic regression, "ordered logit," which requires sequencing the dependent categorical variable. The ordered logit model produces coefficients that estimate the factor's impact on the likely value of the dependent variable, all other factors being held equal. The validity of ordered logistic regression is also based on the test of parallel lines, which relies on the assumption that the coefficient estimates do not vary significantly depending on the level of the dependent variable. This assumption was validated using a test of non-parallel lines. The result was failure to reject the null hypothesis (parallel lines) at the $p < .10$ level, with a significance value of .185.

Table 4 contains the results of the ordered logistic regression. The performance of the overall model is represented by χ^2 of 40.222, which establishes a significant difference ($p < .05$) between the model and the null hypothesis that all coefficients are zero. The amount of variation accounted for by the model is shown using McFadden, Cox and Snell, and Nagelkerke statistics, yielding values of .068, .081, and .038 respectively. Such values would be substandard levels for multiple regression. Unfortunately, these are not comparable metrics to R^2, which represents the proportion of variation accounted for by a multiple regression model (Long, 1997, pp. 104-106).

Two of the independent variables, *non-quiz GPA* and *attendance mode*, had significant associations with the dependent variable, *quiz grade*, which tended in opposite directions. The negative sign of the *non-quiz GPA* estimate is interpreted to mean that the shift to an adjacent grouping of average grades obtained on the financial assignments, for example from "A" (3.75 to 4) to "B+/A-" (3.25 to 3.74) or from "B+/A-" to "B" (2.75 to 3.24), was associated with diminished performance on the quiz. A countervailing relationship with *attendance mode* means that taking the quiz in class rather than virtually produced a positive result, though only about two-thirds as strong. To illustrate the combined relationship, a student with *non-quiz GPA* in the "A" range (3.75 to 4.00) who attended virtually was approximately four percent more likely (4%) to earn an "A" on the quiz than a student with *non-quiz GPA* in the "B+/A-" (3.25 to 3.74) range who attended in person. But the same virtual attendee was about eight percent less likely (-8%) to earn an "A" on the quiz than a student with an equivalent GPA who attended in person. Interpolation of these results indicates that achieving an equivalent outcome on a quiz required the virtual attendee to have superior academic ability: roughly comparable to a single-mark advantage: "A" (virtual) to "A-" (in-person); "A-" (virtual) to "B+" (in-person); and so forth.

Table 4.
Results of Ordered Logistic Regression

N	Pseudo R-Square	Log Likelihood (null model)	Log Likelihood (fitted model)	Chi-Square	Degrees of Freedom	Model Significance
567	Cox & Snell .068 Nagelkerke .081 McFadden .038	861.008	820.786	40.222	24	.020
Variable/Category		Percentage in Category	Coefficient Estimate	Standard Error	Wald Statistic	Variable Significance
Attendance mode						
Virtual (*no estimate)		37.2%				
In-person		62.8%	.496	0.247	4.032	.045
Non-quiz GPA						
A (*no estimate)		29.5%				
B+ to A-		38.6%	-0.721	0.255	7.972	.005
B		21.6%	-0.884	0.278	10.111	.001
C+ to B-		4.5%	-1.427	0.434	10.794	.001
C		2.3%	-0.977	0.612	2.548	.110
D+ to C-		2.3%	-1.327	0.633	4.394	.036
D		1.1%	-1.508	0.897	2.828	.093
Quiz sequence						
8th (*no estimate)		7.1%				
7th		9.9%	0.258	0.482	0.286	.592
6th		12.3%	-0.010	0.468	0.000	.983
5th		14.1%	-0.121	0.463	0.068	.794
4th		13.9%	0.184	0.469	0.153	.695
3rd		14.5%	0.136	0.463	0.086	.770
2nd		14.1%	0.329	0.476	0.479	.489
1st		14.1%	-0.141	0.476	0.087	.767
Virtual quiz experience						
7 (*no estimate)		0.4%				
6		1.4%	0.806	1.539	0.274	.601
5		3.0%	0.988	1.460	0.458	.499
4		3.9%	1.744	1.475	1.398	.237
3		5.1%	1.573	1.453	1.173	.279
2		9.2%	1.012	1.407	0.517	.472
1		12.3%	0.703	1.397	0.253	.615
0		64.7%	1.033	1.400	0.545	.460
Semester sequence						
4th (*no estimate)		23.9%				
3rd		27.3%	-0.212	0.274	0.599	.439
2nd		22.7%	0.314	0.295	1.133	.287
1st		26.1%	0.128	0.281	0.208	.648

* Highest value of each category corresponds with cumulative probability of 1, producing no coefficient.

Inspecting the Wald statistics in Table 4 shows that the associations of the *non-quiz GPA* with *quiz grade* were quite significant ($p < .01$) for the most common values, encompassing the "C+/B-" range and above, which accounted for nearly 95 percent of the sample. Lower Wald values and associated statistical significance for the "C" range and below are of minimal concern, given the very low frequencies in these categories. The association between *attendance mode* and *quiz grade* produced adequate statistical significance, at the $p < .05$ level. The direction of the relationship was in the anticipated direction, with in-person attendance associated with superior performance on the quiz.

None of the experience-based variables, including students' experience with the quiz format or virtual attendance or the instructor's experience with the technology platform, had any apparent association with outcomes. This lack of relationship among *quiz sequence, virtual quiz experience*, *semester sequence, and quiz grade* failed to demonstrate the anticipated impact of familiarity over time—a learning curve. The absence of experience as a factor materializing in the statistical results is surprising.

In view of diminished performance on the quizzes by virtual attendees, which were based on the portion of the lectures dealing with contextual and political facets of budget, the question arises about effective transmission of the remainder of the lecture, dealing with the mechanics of completing the financial assignments. Table 5 contains the results of a regression model relating absences and virtual attendance to the GPA on financial assignments. The model also included control variables, semester sequence and gender, although these had no effect. The level of virtual attendance had negligible association with GPA on financial assignments, which was the core performance metric for the course, while there was a slightly negative, marginally statistically significant ($p < 0.10$) association with absences: approximately one-tenth letter grade reduction in the grades on applied financial assignments per absence.

Table 5.
Results of Regression Model Relating GPA on Financial Assignments to Attendance Attributes

N	R^2	Adjusted R^2	F Value	P > F
88	.047	.001	1.027	.398
Variables	Coefficients	Std. Error	T statistic	Significance
(Constant)	3.413	N/A	N/A	N/A
Absences from class	-0.120	0.072	-1.666	*.099
Virtual attendances	-0.005	0.026	-0.199	.843
Gender (positive = female)	0.106	0.143	0.741	.461
Semester sequence	-0.025	0.059	-0.429	.669

* Significant at the $p < .1$ level.

Findings

The most important finding is the diminished teaching presence in conveying some of the lecture material to virtual students. While significant in the limited terms of this study, this finding does not generalize across applications of webinar technology to distance education for a number of

reasons. First, the lecture-based quiz is a somewhat idiosyncratic pedagogical choice, lending itself to testing a very narrow aspect of the educational experience. In comparison with the instantaneous feedback through quizzes, performance in the core focus of the course, the applied financial assignments, provided a more fundamental evaluation of the combined effectiveness of the lecture with other elements of the learning process. The enhanced presence in other facets of the CoI model—based on the ability to reflect; follow up aspects that were not initially understood, for example by email; and, most crucially, to submit drafts of the financial assignments—engaged students and the instructor in a much broader and more sustained way. The undifferentiated performance for the core of the course, the applied financial assignments, irrespective of students' mode of attendance demonstrates that the diverse means of obtaining and synthesizing knowledge made it possible to surmount apparent technological, environmental, or pedagogical limitations of web-based broadcasting to achieve the primary learning outcomes.

A quite surprising finding is the absence of a significant experiential factor. The clearest expectation was that learning through the experience of virtual attendance would contribute to absorption of lecture-based material more fully, manifested in superior quiz grades by habitual virtual attendees. But, as results in the preceding section showed, this was not the case. Possible explanations include an initial Hawthorne effect (Rainey, 2009, p. 34) followed by gradual diminution, as the novelty and distinction of participating in an experimental trial wore off. Thus, greater familiarity could have contributed to facility with the technology, at the same time that diminished interest or heightened impatience with technical issues detracted from the keenness with which students participated. This explanation is quite speculative, accounting for a single plausible reason, among many possibilities, for the observed failure to improve over time. Another potential rationale for the absence of an observable learning curve is that the webinar technology may have posed a low threshold of adaptation for technologically savvy students—considerably more experienced with audio-visual content delivered over the web than their instructor, of an earlier generation. Similarly, the quiz format itself may have presented a readily surmountable challenge, given the intended ease of this low-stakes testing mechanism, which would account for the lack of improvement by either category of attendees over the course of the semester. Finally, failure by the instructor to eliminate or even reduce the slight deficit in virtual student performance on the quizzes across four semesters may indicate the intractable nature of differences between the virtual and in-person environments. But the stubbornness of this result could equally plausibly indicate that the audio-visual quality issues noted by students using the recordings (see Table 6 below) remained problematic throughout the trial. This possibility is buttressed by the dynamism of the technology used from semester to semester (see Table 1). Changing the test environment admittedly detracted from the reliability of results, but did represent an accommodation of another purpose for this technology trial, which was to pursue a workable, cost-effective solution.

A secondary rationale for this trial of broadcasting technology was to reuse recordings of the face-to-face section of the public budgeting course as a supplement to the course's online section. Although access to the recorded lecture was asynchronous and in theory duplicated the textual material provided online, some students expressed a preference for reinforcing the material by watching the recording. The recordings were also furnished to students in the face-to-face section. Some of the comments students provided are contained in Table 6. There was no mechanism for comment without attribution, which could have limited negative reactions to the technology, although students appeared willing to share criticism as well as positive feedback.

Table 6
Selected Student Feedback on Recorded Lectures Provided Asynchronously to Online Sections

Semester	Student Comment
1st	Love it! This is my 1st experience with technology like this in an on-line course and it has immensely contributed to my grasp of the course content. In the past, I have preferred to take traditional lecture courses. I always felt that I got more out of a classroom setting especially with the instructor clarifying topics and delivering immediate feedback. That is one down side to the webinars. However, this is the next best thing and I feel as though I am getting everything a traditional course has to offer except the ability to ask questions.
1st	Some of the technical problems that I ran into involved the program stopping and restarting while the professor was talking. Also, I found it difficult to hear the class members talking and asking questions. If the class talked a lot I was unable to hear what most of them had to say. Perhaps, more microphones could be added throughout the class room so the audio is clear and easy to hear.
1st	I wish that there was a way that it could be more interactive as far as being able to have live chat attached with it. Outside of that the software is great.
1st	I can't really say anything about it because those types of webinars and broadcasts don't really help me because of my disability. So I don't see any benefit in this for me.
1st	One thing I would like to see added is a brief introduction and directions for the use of the webinars at the beginning of the course. This way people would understand up front the advantages to webinars and immediately start using the technology. I wish all my online courses had used webinars. I feel as though I have missed out by not having been able to take advantage of this technology earlier.
2nd	I liked the webinar recorded lectures, and I think that they are a good idea. However, at times your voice did not sound clear enough for me to understand and I believe that could be adjusted.
2nd	The webinars and broadcasts were a great supplement to the lecture notes provided through Webtycho. Besides the technical issues with the audio, I thought they were really good. I also liked the document sharing feature. I haven't had experience with a similar program in any of my other classes so I really do not have anything to compare the program to but I would recommend using again.
2nd	The webinars and broadcasts were useful for those who need more class lecture instruction. I did use them for clearer explanation on the assignments, although they were often fuzzy and long. Perhaps only recording those specific times when you are explaining material would be beneficial. I don't know how the recording function works but having the ability to hit record and stop throughout the lecture cuts out a lot of unnecessary "class" stuff.
2nd	I really don't have much experience with other similar software, but I do really appreciate that of all the online courses I've taken, there is finally something that allows for a lecture or interaction type atmosphere. The sound was a little difficult to hear sometimes…. Probably the most annoying aspect was the inability to "rewind" like you are able to fast forward. If I missed something and tried to go back, it often took awhile to reload the entire lecture, unless I was doing it wrong.

3rd	I enjoyed having the recorded lectures available. They helped clarify questions about the topics and added a "personal touch" to an otherwise impersonal online format. I only watched one lecture, but that was due to time constraints on my part…. Just be careful of camera position because sometimes you end up with a glare.
3rd	I think the recorded lectures were very helpful when I could hear what you were saying. The audio quality is very poor. I am currently trying to listen to the guest lecturer and cannot hear a word.
3rd	I thought the recorded lectures were a helpful tool that I could use. I only used them a couple of times when I was confused on the excel [financial] assignments, but they gave me some clarification and gave me a better understanding of the material.
4th	Apart from the flexibility that the Elluminate provides with accessing the lectures (which are quite long, I should note), it also made me feel related to the learning process as I realized that my questions on the material are shared with the other students. The only two problems I faced using this experimental project are the sound quality and logging in. There was a lot of background noise.
4th	I found it difficult to hear the audio recordings at times, making the lecture hard to follow. Otherwise I found the recordings to be a good way to reinforce lessons read online.
4th	My only complaint of the recorded lectures would be the sound quality. Sometimes I couldn't hear what was being said, or questions that were asked by students. But I do not know if this is the fault of the software or bad placement of the microphones.
4th	I think the lectures are helpful and the software is interesting but not necessarily user friendly. I would also have enjoyed the lectures more if I was looking at the front of the class instead of your back. If the camera could be relocated so as to give the viewer the experience of sitting at the back or middle of the class - facing front - then I think I would have been able to retain information better.

Discussion

The rationale for undertaking this research was the feasibility of a technical solution that only recently has become more affordable, and, thus, widely available. Any judgment about the advisability of localized, non-institutional implementation of web-mediated broadcasts is beyond the scope of this research. The preceding sections surfaced considerations bearing on the choice by individual instructors to pioneer this type of solution. Until the widespread availability of web-mediated distance education, both synchronous and asynchronous, is realized in the foreseeable future, such a choice will confront many educators, as we struggle to take advantage of technologies at hand to promote effective learning, while being less and less tied to a location.

The observed impact on at least one element of the CoI model, teaching presence, poses a serious issue to be confronted. Further research is needed to establish the extent to which the diminished presence noted here may generalize to other environments, particularly those where production-quality hardware, software, and technical support offer greater stability, reliability, and performance. Yet this research also revealed an apparent resilience in the learning process to the observed shortcomings in teaching presence, making it possible to overcome technological, pedagogical, or environmental deficiencies that appeared to prevent faithful re-creation of the

classroom experience over the Internet. Presumably by compensating in other dimensions of the CoI model, my students and I were able to leverage capacities beyond the scope of this research, such as email-based inquiries, review of drafts, reflection by solitary students, and discussion among peers, to equalize the results achieved by virtual and in-person attendees for the financial assignments, which constituted the core of the course.

The CoI framework has provided a meaningful assessment of the student experience in key facets of the learning process. This study extends that assessment by adding a performance dimension, whereas prior research has been overwhelmingly survey-based. The incorporation of synchronous learning also represents an extension for research rooted in the CoI framework. Yet the future path for studies examining the dimensions of CoI tends toward greater integration of the dimensions, rather than separately focusing on each dimension (Garrison & Arbaugh, 2007). Existence of an integrated, validated survey instrument (Swan et. al., 2008) supports this goal.

Incorporating quizzes such as those used here to assess a segment of student performance would pose a challenge in research employing a comprehensive CoI instrument. An idiosyncratic structure with an unusual grading policy supported use of targeted quizzes in my course, but that is hardly a reasonable choice in most courses. Nevertheless, there could be utility in establishing which elements within the integrated framework represent special challenges under a particular format and where the compensating strengths are drawn upon to mitigate those challenges. In this research, learning based on the synchronous virtual attendance of a traditional lecture apparently did not achieve quite the same level as the face-to-face equivalent. Presumably, non-lecture portions of the course compensated. But parsing the effects of interrelated elements of a learning model and their cross-cutting influences through surveying students seems to be a tall order. It is possible that technological tools beyond the scope of this research may play a role. Synchronously polling students, checking responses, and tracking the questions and reactions posted, all of which the technical solution used here supports, may provide granular data, able to complement multi-faceted surveys. However, the feasibility of this level of technical engagement by the instructor should not be underestimated.

The burdens placed on the instructor doubling as technician are real and palpable to students regardless of their mode of attendance. Dedicated technical support represents a crucial requirement to proceed to the next level of experimentation with webinar technology. Cautioning students about the experimental nature of the learning environment is another necessary step, as measuring outcomes would become virtually impossible to isolate from influencing outcomes. Whereas the tangible benefit, enjoyed by the majority of the students in this study, of avoiding the commute, at least once, to an inner-city university for an evening class seemed to compensate somewhat for the occasional technical misstep and contribute an overall positive reception of the trial, this was by no means an inevitable result. The line between technologically enhanced learning and gadgetry run amok is fuzzy and easy to cross. As web-mediated educational aids become more affordable and ubiquitous, this issue is likely to represent an ever greater concern for the mass of educators: most likely to be neither early- nor late-adopters of technology.

Notes

1. This research was supported by a grant from the Bank of America Center for Excellence in Teaching. A subsequent study funded by a follow-on grant encompasses courses taught by three instructors, each using a different commercial webinar service with extensive market presence.

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