Lecture Capture in Large Undergraduate Classes: What is the Impact on the Teaching and Learning Environment?

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Abstract

Many higher education institutions are now digitally capturing lectures in courses and making them available on the web for students to view anytime and in anyplace. This study is an attempt to understand the relationship between student perceptions of lecture capture and academic performance in large undergraduate courses where the practice is most commonplace. Students in five large undergraduate courses (N=439) responded to a survey on their perceptions of lecture capture used in their course and academic performance was measured by the final course grade. Results suggest that higher achieving students view recordings significantly less often than low achievers. High achievers also tend to fast forward and view certain sections of recordings only once, whereas low achievers view the entire recording multiple times. We conclude that lecture capture is more likely to be of benefit to low achieving students.

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1. Introduction

Although web-based lecture capture technology has been available for over a decade, institutions of higher education are just recently beginning to employ it, particularly in large undergraduate classes (Deal, 2007; Evans, 2008; McGarr, 2009; Scutter, Stupans, Sawyer, & King, 2010; Traphagan, 2005; Woo, Gosper, McNeill, Preston, Green, & Phillips, 2008). Lower cost of the lecture capture technology, more students having access to computers and smart mobile devices, and the greater availability of broadband connections is making its implementation more viable than in the past. Added to this, students appear to want access to recorded lectures to make up for missed lectures, to improve content retention, to review lectures before class, and for general convenience (Nagel, 2008). Indeed, many major U.S. institutions (e.g., University of California at Berkeley, University of Wisconsin, University of Texas at Austin) and international ones (e.g., University of Toronto, Kings College London, Qatar University, National University in Singapore) have now adopted the technology. Lecture capture involves the recording of an instructor's presentation and making the recording available for students on the web. Typically, PowerPoint slides and the instructor's voice are captured, and sometimes a video recording of the instructor and writing on a whiteboard are included. Recordings are made available to students for viewing or downloading at course websites, Youtube EDU, or Apple's iTunes U. Students are then able to view recordings as often as they want, whenever they want, and fast forward and replay sections of the lecture that they wish to view according to their preferences and needs.

Although many faculty worry that students will no longer attend lectures and "classroom seats will collect dust" once lectures are available online (Young, 2008, p. A1), many institutions are moving ahead with plans for introducing lecture capture with the assumption that the technology will add value to the student learning experience. Unless academic value accrues for students, however, one must question whether the technology is worth the time investment on the part of faculty, the financial outlay required by the

institution for its purchase and support, and the human resources needed to train faculty to use the technology (Owston, 1997). Therefore, the goal of this study was to contribute to the understanding of lecture capture and its relationship to academic performance with the view of informing institutional policy. In particular, we investigated the relationship between academic performance in large undergraduate courses where students had access to recorded lectures and attendance, frequency of access, viewing patterns, in-class behavior, and value of including video of the instructor.

2. Review of literature

Both theoretical and empirical research findings are proffered in the literature for the use of lecture capture. From a theoretical perspective, Mayer's (2001) cognitive theory of multimedia learning is frequently cited. This theory suggests that information being presented in the visual and auditory modalities operating simultaneously results in superior learning, particularly in increased retention and transfer of information, as it reduces the student's cognitive load and optimizes the use of working memory. Recent studies offer some support for this underlying assumption by indicating that the recorded lecture format most favoured by university students has been one that presents instructors' audio narration in synchrony with their PowerPoint presentations when compared to, for example, audio only or only a video of the instructor (Debuse, Hede, & Lawley, 2009; Griffin, Mitchell, & Thompson, 2009; McKinney, Dyck, & Luber, 2009).

Bassili (2008) used media richness theory to explain why some students prefer to watch lectures online rather than to attend face-to-face lectures. This theory suggests that different media have different degrees of richness based on their ability to reproduce the information transmitted over them (Daft & Lengel, 1984; Daft, Lengel & Trevino, 1987). For example, e-mail is less rich than telephone communication because of the latter's ability to transmit language nuances and verbal cues; similarly, video conferencing is richer than teleconferencing, but less rich than face-to-face discussion which is considered to be the richest mode of communication. According to the theory, communication is optimal when the capabilities of the medium are matched to the communication task at hand. When information is ambiguous or a person is uncertain, the

person will seek a communications medium that can best resolve the ambiguity or uncertainty; on the other hand, unambiguous information can be communicated by a less rich medium. Thus, when faced with a decision to attend a lecture or watch an online recording of the lecture, Bassili found that students would attend live lectures when they expected the learning content to be difficult, but would watch recordings when they perceived the content less difficult, a finding consistent with media richness theory.

Empirical evidence suggests that providing students with online captures of in-class lectures supports student learning in several ways. First, it appears to increase students' satisfaction and enjoyment with courses by combining lecture capture with face-to-face instruction (Bongey, Cizadlo, & Kalnbach, 2006; Brecht & Ogilby, 2008; Greenberg & Nilssen, 2009; Secker, Bond, & Grussendord, 2010; Veeramani & Bradley, 2008; Woo et al., 2008). Lecture capture aids students' understanding of confusing or complex information and helps clarify issues or questions by enabling students to navigate the lecture recording for later studying of the lecture (Bongey et al., 2006; Chiu & Lee, 2009; Savoy, Proctor, & Salvendy, 2009). Students seem less stressed and anxious when they can take comprehensive notes of attended lectures later on at their own pace without worry of missing information and they can catch up on missed lectures (Harpp, Fenster, Schwarcz, Zorychta, Goodyer, Hsiao, & Parente, 2004). Lecture capture offers students greater flexibility to learn at their desired speed, setting, and with the most suitable tools (*e.g.*, listening to recordings at home or while commuting; playing audio recordings when reviewing lecture notes) (Copley, 2007). Additionally, the technique gives students active control over their learning by allowing them to listen to entire recordings or particular segments, listening more than once, manipulating slides, browsing and pausing at challenging sections, and using other navigation options (Traphagan, 2005).

Despite the above advantages, the effects of lecture capture on academic performance are mixed. Some studies suggest that lecture capture helps students achieve better test scores (Veeramani & Bradley, 2008; Woo et al., 2008); in particular, the mode of synchronous PowerPoint slides with audio streaming was found to be most effective in yielding higher test scores (Griffin et al., 2009; McKinney et al., 2009). There is some evidence that

students using lecture capture perform similar or better and engage more in classroom-based activities, compared to students exposed only to traditional in-class lectures (Day & Foley, 2006; Traphagan, 2005). Other studies showed no significant impact for the use of lecture capture on students' grades and examination performance (Bassili, 2008; Harpp et al., 2004; Dey, Burn, & Gerdes, 2009). Proponents of the lecture capture method argue that the use of lecture capture is less likely to improve learning and teaching unless the purpose of its use harmonizes with course objectives and students' academic needs. In this way, lecture capture cannot be considered as a substitute for the "live lecture" experience, but rather as a supplement and enrichment of it (Harpp et al., 2004; Traphagan, 2005).

Students tend to believe that lecture capture helps their performance by alleviating academic anxiety and improving the quality of their learning experiences (Bongey at al., 2006; Deal, 2007; Traphagan, 2005). Indeed, students highly value lecture capture. On a recent large-scale survey (N~7270) carried out at the University of Wisconsin-Madison (Veeramani & Bradley, 2008), some 82% of undergraduate students indicated their strong preference for the provision of recorded lectures over the Internet to compliment in-class lecturing. (Interestingly, over 60% of students said that they would pay for lecture capture services.) According to recent studies, university students favor audio recordings of in-class lectures in synchrony with PowerPoint slides (when compared to, for example, audio only or only a video of the instructor) as this format helps them study more efficiently by re-visiting the lecture content (Brittain, Glowacki, Ittersum, & Johnson , 2006; Debuse et al., 2009; Griffin et al., 2009; McKinney et al., 2009).

A concern often expressed by faculty is about the negative impact lecture capture may have on students' willingness to attend lectures arguing that the use of recorded lectures would replace or that it will diminish the importance of the classical lecture and detach students from university experience or academic culture (Taylor, 2007). The literature provides mixed results on the influence of lecture capture on student attendance. Some research suggests that lecture capture has minimal impact on attendance of in-class lectures. Researchers have found that a relatively small number of students (ranging from

10 to 15%) are tempted to skip actual lectures because they view lecture capture as a complete substitute for class attendance, while the overwhelming majority have not changed their class attendance patterns. (Bongey et al., 2006; Copley, 2007; Deal, 2007). However, other studies indicate that the provision of recorded lectures negatively impacts student attendance of in-class lectures. Henke, Lawrence, McMartin, Maher, Gawlik, and Muller (2003) found in their large scale study at UC Berkeley that 31% of students reported attending lecture less than the normal three times per week and 25% stopped attending because of the webcasts. In another study, Traphagan (2005) reported that 51% of students attended classes with a lecture capture, compared to 60% of students with no access to recorded lectures. The study reported a moderate correlation ($r = .40$, $p < .05$) between viewing of recorded lectures and student attendance. When students were asked about their attitude towards viewing recorded lectures instead of attending lectures, 71% agreed or strongly agreed that they skipped class because of the availability of recorded lectures. At the same time, 55% of students chose both options – recorded lectures and traditional lecture.

Recent studies suggest that the reasons for such negative impact of lecture capture on attendance lie in several factors that might induce students to attend face-to-face lectures: (a) the higher degree of informational richness of live lecture content (Bassili, 2008; Brittain et al., 2006); (b) student need for structured learning (Copley, 2007); (c) the social interaction and shared experience live lectures can provide (Bassili, 2007; Copley, 2007; Dey et al., 2009); (d) the absence of the video of the instructor in lecture recordings (Bongey et al., 2006; Dey et al., 2009); and (e) the perceived difficulty of learning the lecture content (Bassili, 2007). In addition, Holbrook and Dupont (2009) found that the level of student academic maturity might affect class attendance: freshmen are more likely to reduce their class attendance than students in senior years.

Overall, the inclusion of lecture capture in courses is widely favored by students and it appears to offer several advantages to facilitate their learning experience. Questions remain about whether students are able to use it as a substitute for lecture attendance and still achieve well in their courses, whether frequent use of lecture capture leads to

improved academic performance, whether there are efficient ways for students to view the lecture recordings, how reported changes in in-class behavior associated with lecture capture are related to performance, and the extent to student preferences for viewing the instructor is related to course grades.

3. Research Questions

To address the above unresolved issues, we formulated the following research questions to investigate in this study:

1. What is the relationship between student attendance and finals course grades when complete recordings are available for all lectures?
2. What is the relationship between frequency of access of lecture recordings and grades?
3. What is the relationship between viewing patterns and grades?
4. What is the relationship between in-class behavior during lectures and grades?
5. What is the relationship between students' preferences for viewing the instructor in videos and grades?

4. Methodology

We investigated the research questions in six large freshman classes in a faculty of health at a major urban university in Canada. The present project was a sub study of a larger investigation into students' use of the Moodle course management system in these courses. For the 12 week duration of the courses, each 3 hour weekly lecture was captured using the Camtasia Relay software (http://www.techsmith.com/camtasiarelay) which recorded the instructor's voice and PowerPoint slides. Links to the lectures were made available immediately after class in Moodle or students could subscribe to the videos at iTunes.

Toward the end of the course instructors announced in class and posted in their course Moodle, a link to an online questionnaire which was the main source of data for the study. The researchers, who were at arm's length to the courses, also paid visits to each class to explain to the students the purpose of the research and to answer any questions.

Students were then asked to voluntarily respond to the questionnaire and to enter their student number. The questionnaire contained multiple option questions that related directly to each of the research questions. The wordings of these questions are summarized below in the results section.

A total of 2376 students were enrolled in the courses, which averaged 396 students per class. Of these, 869 or 37% of the students responded to the questionnaire; however, only 439 of the total group or 19% volunteered to provided their student ID number. This study is based on the later group of respondents because the student ID was necessary for us to obtain each respondent's final course grade. Grades awarded in the courses were based on a 10 point scale, with 9 representing an A+ and 0 representing an F. Typically, when calculating final course grades, instructors took into account multiple choice exam scores, mid-term tests, and assignments. In this study, we use the term student grades, achievement, and academic performance as interchangeable terms. Attendance in lectures was not compulsory and the instructors did not keep records of attendance.

A potential limitation of this study is that we relied on student self-reports for matters such as attendance, viewing patterns, and in-class behavior. However, extensive research suggests that students are accurate and credible reporters of their educational experiences (Kuh, 2001). In summarizing this research, Kuh stated that self-reports are most likely to be valid when:

> (1) the information requested is known to the respondents; (2) the questions are phrased clearly and unambiguously; (3) the questions refer to recent activities; (4) the respondents think the questions merit a serious and thoughtful response; and (5) answering the questions does not threaten, embarrass, or violate the privacy of the respondent or encourage the respondent to respond in socially desirable ways" (Kuh, 2001, pp. 3-4).

We designed our questionnaire to satisfy these conditions and believe that we were able to meet them.

5. Results and Discussion

5.1 Research Question 1: Lecture Attendance and Student Grades

Students were asked what effect, if any, the availability of lecture recordings had on their normal level of lecture attendance compared to courses where such recordings were not made available. Table 1 below shows that 43% said that their attendance was about the same as courses without recordings. A slight plurality, 55%, indicated that their attendance was less than normal with 10% responding that they stopped attending lectures entirely. Two percent of students reported that they attended more often. The mean grade of those who stopped attending was the highest (6.19), while those who attended more often was the lowest (4.89). One-way ANOVA results, however, showed that the differences in grades between response categories was not significant [$F(1, 5) = 0.887$, $MSE = 4.958$, $p = .490$]. Thus, while most students attended less because of the availability of lecture capture, there is no evidence to suggest that their grades suffered as a result.

Table 1

Change in Attendance Pattern and Mean Grades (N=439)

Attendance Pattern Change	Frequency (%)	Mean Grade
Stopped attending lectures completely	44 (10)	6.19
Attendance was less than 50% of normal	52 (12)	5.40
Attendance was between 50% - 75% of normal	70 (16)	5.44
Attendance was between 75% - 100% of normal	74 (17)	5.68
Attendance rate was the same	190 (43)	5.59
Attended more lectures than normal	9 (2)	4.89

Our finding that students, on the whole, reported attending class slightly less is generally consistent with the literature (*e.g.*, Deal, 2007). What is also consistent with the literature is that some students stop attending the lectures entirely. In a UC Berkeley study, 25% of students reported that they did not attend lectures in a very large introductory chemistry course because they had access to video recordings (Harley, Henke, Lawrence, McMartin, Maher, Gawlik, & Miller, 2003). Bongey et al. (2006) found that only 6% did not attend lectures. Thus our finding of 10% who stopped attending is within the range of what might be expected. What is interesting in our study is that these students tended to be the ones with the highest final grades, even though we did not find a statistically significant relationship between grades an attendance. No studies were found in the literature that address this specific question, but we speculate that higher achieving students had the confidence and self discipline to study the lectures only online as they were verbatim from the class lectures, including course announcements, whereas lower achieving students may not have had the confidence to rely solely on them. Additionally, all students had access to the course Moodle site that contained course resources and links to relevant readings and websites, so the higher achievers may have found that attending class was redundant.

5.2 Research Question 2: Frequency of Accessing Recordings and Student Grades

Students were free to access lecture recordings during their course at anytime from anyplace. They were asked to respond approximately how often they viewed the recordings. While there was considerable variability in the reported frequency of access to the recordings (see Table 2), over half of the students (56%) accessed them 2 or 3 times a week or more suggesting that they were making regular use of them. Somewhat unanticipated was that a minority of students (11%) reported viewing them at least once per day. These finding suggest that students in the current study made somewhat greater use of the recordings than reported in other studies. Other researchers report that only about a third of students tend to watch videos within a week of lectures (Brotherington & Abowd, 2004; Traphagan, 2005), whereas Zupancic & Horz (2002) found that 42% watched recordings within two weeks. Our finding that 20% viewed the videos only once a month or less suggest that these students watched the videos just before exams and

midterm tests. Although detailed usage records were not kept, this finding is consistent with that of other studies (*e.g*., Deal, 2007).

Table 2

Frequency of Accessing Lecture Recordings and Mean Grades (N=434)

	Rate of Access				
Variable	Once per month or less	2 or 3 times per month	2 or 3 times per week	4 to 6 times per week	1 or more times per day
Frequency (%)	85 (20)	109 (25)	129 (30)	65 (15)	46 (11)
Mean grade	6.27	5.80	5.64	4.69	5.11

The rate of access was significantly related to student grades [$F(1, 4) = 4.995$, $MS = 26.83$, $p = .001$]; therefore, a Tukey post hoc analysis was conducted. Probabilities for simple contrasts with the Tukey test are shown in Table 3. These findings indicate that students who accessed the recordings once per month or less often achieved significantly higher grades than those who accessed them 4 to 6 times per week or more often. Additionally, students who accessed them only 2 to 3 times per month scored significantly higher than those who viewed them 4 to 6 times per week. No other contrasts were significant.

Two interpretations of these results seem plausible. First, it may be that the higher achieving students do not need to access the supplementary videos as often in order to succeed in the courses, thus reflecting an efficient learning strategy of viewing them only when they feel necessary. Another interpretation might be that the lower achieving students lack the confidence, comprehension skills, and/or note taking ability so that they feel that they have to view the videos more often. This finding may also provide an explanation why researchers have reported mixed findings on the impact lecture capture on achievement as discussed in section 2 above. None of the above studies provided analyses of the relationship between frequency of viewing and grades, except that Traphagan (2005) found that students who expected to receive an “A” in their course

watched the lecture recordings more often than those who expected a "B." Nonetheless, our findings suggest that lecture capture may be of more benefit to lower achieving students. Pinder-Grover, Millunchick, Bierwert, and Shuller (2009) provide some support for this notion. The researchers found a significant correlation between final course grade and frequency of viewing recorded lectures ($p \leq .01$) in one of two years of engineering classes studied. From the graphical presentation of their findings, A and B grade students appear to be "very low" users of recordings (defined at 1 to 10 viewings).

Table 3

Post hoc Tukey Test Probabilities for Rate of Access

	Rate of Access			
Rate of Access	2 or 3 times per month	2 or 3 times per week	4 to 6 times per week	1 or more times per day
Once per month or less	.626	.259	.000 **	.045*
2 or 3 times per month		.974	.017*	.416
2 or 3 times per week			.059	.683
4 to 6 times per week				.879

* $p < .05$ ** $p < .01$

5.3 Research Question 3: Viewing Patterns and Student Grades

Students were asked to choose one of five statements that best described their pattern of viewing lecture capture videos. These statements ranged from "Did not view the lecture recording" to "Fast-forwarded to sections and watched them multiple times." From Table 4, it can be seen that 27% of students reported viewing the entire recording only once and 14% watched the whole video multiple times (total 41%). This finding is generally in line with Traphagan (2005) who reported that approximately 45% of students tended to view the entire lecture rather than picking out specific sections of the videos to view. Nearly

identical findings were also reported by Pinder-Grover et al. (2009). Also of interest in this table is that the largest single response category (34%) said that they watched the entire recording once and sections multiple times, and that 8% responded that they did not watch the videos at all.

Table 4

Frequency of Viewing Behaviors and Mean Grades (N = 439)

	Viewing behavior					
Variable	Did not view lecture recording	Watched recording once	Watched recording multiple times	Watched the entire recording once and sections multiple times	Fast-forwarded to sections and watched them once	Fast-forwarded to sections and watched them multiple times
Frequency (%)	37 (8)	118 (27)	63 (14)	150 (34)	32 (7)	39 (9)
Mean grade	5.92	5.84	4.63	5.43	6.75	5.90

There was a significant relationship between viewing behavior and grades [$F(1, 5) = 4.435$, MS = 23.82, $p = .001$]. The Tukey post hoc comparisons are given in Table 5. The comparisons indicate that students who fast-forwarded to sections of the videos and watched them once achieved significantly higher than: (1) those who watched them multiple times ($p = .000$), and (2) those who watched the entire recording once and sections multiple times ($p = .043$). The comparisons also show that students who watched the recordings only once scored higher than those who watched them multiple times ($p = .012$). This finding suggests that the higher achievers used the videos only to clarify or review specific topics, not to review the entire lecture. The lowest achievers tended to be those who watched whole videos multiple times.

Table 5

Post hoc Tukey Test Probabilities for Viewing Behavior

	Viewing behavior				
Viewing behavior	Watched recording once	Watched recording multiple times	Watched the entire recording once and sections multiple times	Fast-forwarded to sections and watched them once	Fast-forwarded to sections and watched them multiple times
Did not view lecture recording	1.000	.082	.864	.674	1.000
Watched recording once		.012*	.713	.360	1.000
Watched recording multiple times			.198	.000**	.083
Watched the entire recording once and sections multiple times				.043*	.875
Fast-forwarded to sections and watched them once					.637

* $p < .05$ ** $p < .01$

5.4 Research Question 4: In-class Behavior and Student Grades

One of the arguments presented to justify lecture capture is that having the lectures available outside of class will encourage students to better concentrate in class on the lecture and participate more actively in class rather than focusing on note taking. Therefore, students were asked six Yes-No questions about their in-class behavior in comparison to other courses they were taking that did not have lecture capture. From Table 6, it can be seen that nearly three-quarters of students (74%) reported that availability of recordings made no difference to their in-class behavior. Students were almost evenly divided between Yes and No on two other questions: (1) whether they followed discussions more closely and (2) whether they focused more on the lecture and less on note taking. The vast majority (95%) indicated that having the recordings available did not lead them to pay less attention to the in-class lecture. Not unexpectedly, because of the large size of classes, a very large majority of students responded that they did not participate more in discussions (82%) or ask more questions (91%) as there was likely little opportunity to do so. No significant differences in course grades were found between Yes and No respondents on any of the six questions.

Table 6

Frequency of In-class Behavior and Achievement

Behaviors	Response	Frequency (%)	Mean grade	*F*	*p*
I followed discussions more closely.	No	240(55)	5.67	0.153	.696
	Yes	198 (45)	5.53		
I participated in more discussions.	No	359 (82)	5.59	1.155	. 283
	Yes	79 (18)	5.68		
I asked more questions during the lecture.	No	401 (91)	5.65	1.435	.232
	Yes	37 (9)	5.18		
I paid less attention to the lecture.	No	415 (95)	5.61	0.057	.811
	Yes	23 (5)	5.57		
It made no difference to me.	No	324 (74)	5.51	0.206	.650
	Yes	114 (26)	5.87		
I focused more on understanding the lecture and less on note-taking.	No	213 (49)	5.79	0.925	.337
	Yes	225 (51)	5.44		

Although freeing up students from in-class note taking seems to be a reasonable justification for lecture capture use, our findings do not support this rationale. Other researchers have found changes, however. Copley (2007) reported that of the 84 students who responded to a survey, approximately 40% indicated that they downloaded podcasts "to enable note-taking at their own pace" (p. 395). This response is not a direct measure of whether students did less note taking in class, but it suggests that they did. Brotherton and Abowd (2004) did find that students took fewer notes in class when lecture recordings were available and focused more attention to the lecture. Another change in class behavior was reported by Harpp et al. (2004) who cited an instructor who said that the online lectures reduced student "verification questions" by about 50% which saved 3 to 4 hours per week in lecture time (p. 689).

5.5 Research Question 5: Importance of Viewing Instructor and Student Grades

As mentioned earlier, the lecture capture system used in this study did not include video of the instructor because it simplified the recording process, reduced costs, and reduced downloading time. In order to help the university decide whether they want to include video of the instructor in the future, students were asked about its potential value. Responses to this question are given in Table 7, which shows that almost two-thirds of students (65%) responded that the inclusion of video of the instructor would be "useful" or "essential" in future courses. Only 14% said that it was not needed. No significant differences in grades were found across response categories [$F(1,3) = 0.540$, MS = 3.023, $p = .655$]. This finding suggests that neither the academically weaker nor academically stronger students had a preference one way or the other for the inclusion of video. These findings are consistent with Dey et al. (2009) who found that, while students may prefer to see video image of the instructor, there was no difference in retention or transfer between students who listened to lectures with presentation slides and instructor audio with or without a video image of the instructor. Given their finding, Dey et al. (2009) questioned the wisdom of going to the trouble and expense of providing video in lecture capture recordings.

Table 7

Value of Seeing the Instructor in Video (N = 439)

Response	Frequency (%)	Mean grade
Not needed	63 (14)	5.62
Slightly useful	91 (21)	5.78
Useful	149 (34)	5.68
Essential	136 (31)	5.40

6. Summary and Conclusions

Lecture capture in large undergraduate courses is highly regarded by students as it offers them flexibility to attend classes—or not, it is convenient for them to review lectures when studying, they can catch up on course material when they miss a class, they feel less pressured to take detailed notes in class knowing that they can view the views later,

and students can simply ignore recordings if they do not find them helpful. Whether access to captured lectures actually leads to improved student academic performance is still an open question as studies comparing classes with and without lecture capture show marginal, if any, improvement. In this context, we undertook the present study in an attempt to further understand academic performance in large undergraduate courses that employ lecture capture. We investigated five research questions concerning students' perceptions of various aspects of lecture capture and the relationship of those perceptions to academic performance. Students in five large undergraduate courses (N=439) responded to a survey on their perceptions of lecture capture used in their course and academic performance was measured by the final course grade. Significant relationships were found between these variables for two of the research questions.

The first significant relationship was for research question 2 that concerned how often students viewed lecture recordings. Our findings indicate that students who viewed them once per month or less achieved significantly higher than those who viewed them more often. Even students who viewed them only a few times a month scored higher than more frequent viewers. As discussed earlier, there is some evidence in the literature of a positive correlation between viewing frequency and grades (Traghagan, 2005; Pinder-Grover et al., 2009); however, our finding suggests that lower achieving students may benefit more from lecture capture than higher achievers. It may be that as students gain success in a course—and build the confidence that may come with this success—they will feel less need to review material in the lecture recordings. Therefore, further research is needed to examine the question of who benefits most from lecture recordings and why they benefit.

Research question 3 dealing with viewing behaviors was the second area where we found significant relationships. The highest achieving students fast-forwarded to sections and watched them once, whereas the lowest achievers watched the whole video for each class multiple times or watched the entire recording once and sections multiple times. Von Konsky, Ivins, and Gribble (2009) observed this phenomenon when they described four students in their study who received different grades in an undergraduate software

engineering course. The highest achiever listened to only one hour of recordings and "strongly disagreed" with the statement "when I listened to recordings, I tended to listen to the entire lecture" (p. 592); whereas, the lowest achiever "agreed" with the same statement and reported listening to 8 hours of recordings. The findings for this research question, together with the findings for question 2 above, tend to reinforce the view that higher achievers bring to their studies well-developed and successful learning strategies. Therefore, lecture capture provides minimal added value for them if they attend class, take notes, or study the course content in other ways. Lower achievers are not as likely to have developed these successful strategies and depend more on viewing recordings multiple times in an attempt to make the subject matter "sink in." Again, we call for more research to investigate the differences in lecture capture usage among students of different achievement levels.

Results for the remaining three research questions did not indicate a significant relationship between achievement and attendance (question 1), in-class behavior (question 4), or preference for viewing the instructor (question 5). A surprising finding on research question 1 was that 10% of students reported that they stopped attending lectures entirely, yet they tended to achieve the highest grades of the response categories (although not significantly higher statistically than others). Given the findings above that high achievers watched videos much less often than others, one wonders how they achieved those grades if they did not even attend class. The only conclusion appears to be that they were independent learners who relied on reading the assigned texts and accessing resources at the course website. They may indicate that a group of more able freshmen students who are not challenged sufficiently by their courses and hence do not attend, an observation made by Don Tapscott in his writings about the current generation of young people who have grown up in a digital world (Tapscott, 2009). Our finding of the lack of relationship between in-class behavior and achievement for research question 4 may be an artifact of large classes where there is little opportunity for interaction with the instructor and students are established in their ways of note taking and attending to the lecturer. The finding could also represent student distrust that the recordings will actually be available after each class as technical difficulties could intervene and render

them unusable. (The use of lecture capture was considered a pilot project by the university and no guarantee was offered that the recordings would be available in good quality after every lecture.) Our final finding for research question 5 that there was no relationship between students' desire to view the instructor and achievement was not entirely unanticipated. However, the finding that almost two-thirds of students responded that the inclusion of video of the instructor would be "useful" or "essential" in future courses should give higher education decision-makers some pause. While there may not be any direct academic benefit to inclusion of the instructor video, its inclusion may make the videos more engaging and appealing to students.

Overall, video capture has entered the mainstream for large undergraduate classes as a growing number of institutions implement the process and the costs of providing the service decrease. Decision-makers need to realize that there is unlikely to be any achievement improvement for students on the whole; however, our research suggests that low achievers may benefit most from lecture capture. If this conclusion is supported by further research, the resources required to implement lecture capture are well justified.

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