High Educ (2019) 77:403–421
https://doi.org/10.1007/s10734-018-0275-9

A study exploring the impact of lecture capture availability and lecture capture usage on student attendance and attainment

Martin R. Edwards[1] · **Michael E. Clinton**[1]

Published online: 5 June 2018

Abstract Lecture capture is widely used within higher education as a means of recording lecture material for online student viewing. However, there is some uncertainty around whether this is a uniformly positive development for students. The current study examines the impact of lecture capture introduction and usage in a compulsory second year research methods module in a undergraduate BSc degree. Data collected from a matched cohort before ($N = 161$) and after ($N = 160$) lecture capture introduction showed that attendance substantially dropped in three matched lectures after capture became available. Attendance, which predicts higher attainment (controlling for students' previous grade and gender), mediates a negative relationship between lecture capture availability and attainment. Lecture capture viewing shows no significant relationship with attainment whilst factoring in lecture attendance; capture viewing also fails to compensate for the impact that low attendance has on attainment. Thus, the net effect of lecture capture introduction on the cohort is generally negative; the study serves as a useful example (that can be communicated students) of the pitfalls of an over-reliance on lecture capture as a replacement for lecture attendance.

Keywords Lecture capture · Lecture recording · Student attainment · Lecture attendance

Introduction

The last decade has witnessed growth in the use of lecture capture within higher education (Walker et al. 2014; Henderson 2014). Typically referring to the digital recording of lectures via video and/or audio and their subsequent availability to students online as an additional learning resource, lecture capture's usage is associated with an increasing call for blended-

✉ Martin R. Edwards
Martin.R.Edwards@kcl.ac.uk

[1] King's Business School, King's College London, Bush House, 30 Aldwych, London WC2B 4BG, UK

learning approaches that move away from a sole reliance on face-to-face lectures towards the greater utilisation of different technological enhanced learning tools (e.g. Johnson et al. 2015). The introduction of lecture capture is understood to be widely welcomed by student bodies who appreciate the flexibility that it brings, allowing students to view lecture material multiple times and from varied locations (e.g. Motion-217 submitted to the 2016 UK National Union of Students conference).

Despite its increasing use in higher education or popularity among students, research findings on the impact that lecture capture has on student engagement and attainment are very mixed, as are opinions relating to its utility (with students subscribing to lecture capture benefits to a greater degree than teaching staff, Danielson et al. 2014). This study examines the impact of lecture capture during its introduction on a BSc degree by comparing attendance and performance in the year before versus after lecture capture introduction. The 2 years were very similar in teaching delivery, where the content, teaching staff, rooms and assessment setup remain the same. The study is unique in that it examines two different aspects of the introduction of lecture capture on student engagement and attainment: the effects of lecture capture *availability* to students and the effects of students' *usage* of lecture capture. The study is unique in combining these elements and helps us better understand the potential impact of lecture capture.

Lecture capture availability versus usage

The debate about the effects of lecture capture often masks an important distinction between whether we are talking about the effects of lecture capture due to its introduction as a learning resource versus the effects of the extent to which students interact with lecture capture. With the former, which we refer to as lecture capture *availability*, we reflect on any change in student outcomes comparing before lecture capture is introduced with after its introduction. To fairly examine the effects of lecture capture availability outside of a controlled laboratory setting, it is important that, beyond the change in the availability of lecture capture, conditions of the module over the 2 years remain as similar as possible; we achieve such matched conditions in the current study.

The second way of looking at the effects of lecture capture relates to students' lecture capture *usage*. This is an individual-level variable and represents the degree to which an individual interacts with the resource once it is available. This individual data is often available via the lecture capture software. Also, students may use lecture capture for different purposes, perhaps as a substitute for attending a live lecture or as a supplement to live lecture attendance, and may indeed find it beneficial in a variety of ways. Indeed, research has found that lecture capture is often used as supplemental rather than replacement of live lectures and many students who use it also attend the live lectures (Leadbeater et al. 2013; Witthaus and Robinson 2015). In a recent three-cohort study, Brooks et al. (2014) identified five different classifications of user activity; these were 'high activity', 'just-in-time', 'minimal', 'deferred' and 'non-users'; this indicates that the usage and therefore the benefits gained from usage will vary across the student population.

Some research has considered the extent to which availability and usage of lecture capture correlates with student engagement and attainment. Importantly, no study to our knowledge has examined the effects of the *availability* and *usage* of lecture capture at the same time. This is crucial as it allows us to examine whether students' usage of lecture capture enables them to overcome any shortcomings that the availability of lecture

capture presents. Also, many of the existing studies have relied on self-report data from students regarding either their attendance or their use of lecture capture; such studies are prone to social desirability bias (Karnad 2013). The present research examines both lecture capture availability and lecture capture usage within the same study and draws on objective data for its analysis.

Impact of lecture capture on lecture attendance

There are several reasons why one may expect that the availability of lecture capture will reduce lecture attendance. For example, students may make a rational decision to not attend the lecture on the expectation that they can view it later. Students may believe that their learning experience will be equivalent across the live and recorded lecture formats and that nothing is lost from not attending a physical lecture. Indeed, the convenience of being able to choose when/where to view and/or listen to the lecture could in theory have some benefits to the individual. From a slightly different perspective, lecture capture availability potentially removes a perceived penalty for missing a live lecture as there is a 'second chance' to experience it. Should students find themselves torn between attending a lecture and engaging in an alternative activity (be it social, personal or work related), lecture capture availability makes it easier to choose the alternative activity, with the (perhaps optimistic) belief that they will 'catch up' later. So, one would expect the net effect of lecture capture availability would be negative on attendance in lectures and this would be supported by several studies to date (e.g. Holbrook and Dupont 2009; Traphagan et al. 2010). Thus:

Hypothesis 1: The availability of lecture capture has a negative relationship with student lecture attendance.

The likely effect of greater lecture capture usage on attendance is less clear. One school of thought would be that a greater use of lecture capture would be indicative of students substituting the live lecture from the recorded lecture, and so a negative relationship with attendance could exist. However, as discussed above, research indicates that supplemental use of lecture capture materials is perhaps more prevalent (e.g. Witthaus and Robinson 2015). Indeed, some research supports this further, for example Aldamen et al. (2015) find a positive relationship between viewership and attendance. A possible explanation for this may be linked to different process and cognitive learning approaches utilised by students, with the more engaged students, potentially adopting a deep approach to learning, characterised by internalisation of content, making learning meaningful and personal growth (see Marton and Säljö 1976; Wiese and Newton 2013), being more likely to utilise all possible educational resource available to them. Alternatively, disengaged students, who potentially adopt a more surface approach to learning, characterised by rote memorisation and reproducing facts (see Kember et al. 1995; Marton and Säljö 1976; Wiese and Newton 2013), are less likely to do so. By implication, taking learning approach or pre-existing academic ability into account is likely to help explain the relationship between lecture capture usage and attendance. Given these arguments, we would generally expect the following:

Hypothesis 2: Lecture capture usage has a positive relationship with lecture attendance.

Impact of lecture capture on academic attainment

One would expect that students who engage less in their learning activity will generally not perform as well as more engaged students. If we consider lecture attendance a reasonable measure of student engagement, we would expect to find a positive aggregate relationship between attendance and grades. A raft of research supports such a relationship (Brocato 1989; Newman-Ford et al. 2008; Golding 2011).

One particularly large-scale investigation into the relationship between attendance and attainment by Newman-Ford et al. (2008) found a strong positive correlation between attendance and academic attainment; importantly, the more students were found to attend classes, the less likely they were to fail and the more likely they were to get high grades. To explain this, Newman-Ford et al. draw on existing literature which suggests that, compared with attenders, non-attenders may be less motivated, have more non-study-related demands and be more likely to have to make trade-offs with their time that could negatively impact their results. However, in order to examine the incremental effects of individual lecture attendance on attainment, it seems important to try to remove general, trait-like explanations for the association (e.g. trait conscientiousness, cognitive ability) that may influence both higher attendance and attainment. So, in examining the association between attendance and attainment, controlling for previous academic attainment is important (in this case previous year's average grade). Thus:

> *Hypothesis 3: (a) Lecture attendance has a positive relationship with student attainment (when controlling for general academic ability).*

From the above discussion, we might expect the introduction of lecture capture to have an aggregate negative impact on student attainment because, as discussed, its availability may decrease attendance. However, recent studies find differing results when content is delivered either face-to-face sessions or via online sessions; Bosshardt and Chiang (2016) find similar attainment levels across each delivery mode whilst Roberts (2015) found lower attainment levels for the online cohort. What is even less clear are the effects of online recorded material when it is available in addition to face-to-face lectures. Based on arguments made above, we suggest that a direct negative effect of lecture capture availability on student academic attainment will exist and that this effect will be mediated by the reduction in attendance at lectures. To date, research has not formally tested this indirect relationship. Thus:

> *Hypothesis 3: (b) The availability of lecture capture has a negative relationship with student attainment (c) that is mediated by lower student lecture attendance (when controlling for general academic ability).*

There is some evidence that lecture capture usage may benefit attainment, with studies finding a weak positive relationship between viewership and grades (e.g. Aldamen et al. 2015; Brooks et al. 2014; Traphagan et al. 2010). However, given that those students who use lecture capture may be some of the most engaged students, it may be that this effect can be better explained by a trait-like variable, like academic ability. Vajoczki et al. (2011) and Wiese and Newton (2013) suggest that the impact of lecture capture on attainment will potentially be moderated by the learning approach of students, with those

who adopt a 'deep learning approach' benefiting from lecture capture usage; thus, a positive impact would not be present with students who adopt a 'surface learning approach'. Interestingly, Wiese and Newton obtained performance data on two cohorts before lecture capture was introduced and one after; although the cohorts were very different (in terms of cohort size and demographics) and different instructors taught across the cohorts (which limits one's ability to compare across the cohorts), they found that the post-lecture capture cohort had slightly higher grades. Unfortunately, these authors did not assess the impact of lecture capture viewing on grades, whilst controlling for previous grades of the different cohorts or attendance. Indeed, Mallinson and Baumann (2015), drawing on self-reported data, found that a positive association between lecture capture usage and attainment drops away when attendance is controlled for. We similarly propose that whilst a positive link may exist between objective records of lecture capture usage and attainment, this will be reduced when we account for attendance and general academic ability. Thus:

Hypothesis 4: (a) Lecture capture usage has a positive correlation with student attainment, (b) which becomes non-significant when controlling for attendance and general academic ability.

The substitutive effects of lecture capture usage and live lecture attendance

So far, we have mainly considered the effects of lecture capture usage and attendance in isolation. However, as identified earlier, we know that some students use lecture capture as a substitute for attendance at live lectures and others may use them to supplement attendance at live lectures. This brings forth two questions regarding whether, in terms of attainment, using recorded lectures is a genuine replacement for what is gained from live lectures and then whether supplementary recorded material offers detectable added value for students who already attend the lectures.

From one perspective, we might believe that use of lecture capture is very unlikely to replace live lectures and that heavy use of lecture capture may not allow poor attenders to 'close the gap' (Witthaus and Robinson 2015). The analysis presented by Williams et al. (2012) clearly indicates that whilst there is some evidence for the utility of lecture capture viewing on attainment under certain attendance conditions, 'if a student attempted to almost completely substitute face-to-face lectures with online recordings, then no matter how often they viewed the recordings, they never made up the lost marks from not attending' (p. 210). These perspectives place prime value on lecture attendance as dominant in driving attainment. Yet this perspective clearly opposes others upon which the benefits of lecture capture are largely based, namely that if students use it, lecture capture allows students who have not attended lectures to catch up (to some degree) with those who have. This seems to be an important issue that requires attention when considering the potential merits of lecture capture. To test these different perspectives, we examine the following hypothesis:

Hypothesis 5: The relationship between lecture attendance and attainment is moderated by greater use of lecture capture, such that the deficit in student attainment associated with low attendance is compensated for by a greater use of lecture capture.

Method

Module details and educational context

The module involved in the current study is a compulsory second year undergraduate quantitative research methods course (level 5), within a 3-year BSc degree in the UK. Data come from two matched cohorts of the students: one taught during September–December 2015 and the other over the same period in 2016. Importantly, there was considerable consistency across the 2 years, including the content, timing and location of lectures, teaching staff, and the weighting, timing and setup of assessment elements.

Lecture capture introduction

During the 2015 teaching session, the University began introducing the use of video lecture capture in main lecture theatres across the campus; however, the module leaders made it available only in the 2016 teaching session. Each lecture was videoed and uploaded to the online teaching platform (Moodle) within 12 h of the lecture. The recording involved an audio recording of the lecture, and on a split screen, the student could toggle between viewing a video of the lecturer and viewing the slides presented.

Sample and participants

The number of students enrolled on the module for the 2015 teaching session totalled 161 and 160 students in the 2016 session. In the 2015 session, there were 86 females (53.4%) and 75 males (46.6%); within the 2016 session, there were slightly more females (57.5%) than males (42.5%), though this difference was not significant (chi-square = 0.389, NS).

Measures

Lecture capture availability This variable was operationalised by using a year dummy: 2015 (coded as 1) represented no availability of lecture capture and 2016 (coded as 2) represented availability of lecture capture.

Lecture capture usage In the 2016 session, the module leader was able to view records of substantive lecture capture use. The data available for this measure involved a count of instances where a student streamed more than 5% of any lecture capture. Two downloads were taken: the first set of viewing records were downloaded on the Monday following the final teaching session and second set of viewing records were downloaded the day after the exam. Therefore, there are two measures available for lecture capture usage, one involving term-time viewing and the second involving total viewing (including viewing during the revision period).

By the end of term, the students on the module had viewed the lecture capture material (more than 5% of each capture) 230 times (mean = 1.5 views per student; sd = 3.38), but this was far from evenly spread as 68% of the cohort did not view lecture capture to any significant degree during the term and only 2.5% viewed more than 10 captures during the term. Many more students used lecture capture for revision; the total number of viewings at the time of the final exam amounted to 730 views (mean = 4.56 views per student; sd = 6.41); thus, two thirds

of lecture capture usage occurred during the revision period after the module teaching had finished. To provide a more in-depth test of hypothesis 5, we grouped the students into three lecture capture viewing behaviour profiles: (1) no substantive viewings (66 students/41.3%), (2) viewed between one and five times (46 students/28.7%) and (3) viewed lecture capture more than five times (48 students/30%).

Lecture attendance In both the 2015 and 2016 teaching sessions, the module leader circulated a double-sided A4 list of names for students to sign in the fourth, fifth, and sixth teaching weeks. These were circulated approximately 30 min into the lecture so that late-comers could be included. Not taking attendance in the first 3 teaching weeks allowed students to revert to their natural studying habits (once the initial induction and settling-in period had passed) before attendance monitoring was initiated. In the 2015 session, the module leader was aware that the monitoring of attendance might influence attendance behaviour of the students and thus stopped monitoring after teaching week 6 (in order to keep the duration of the attendance monitoring to a minimum). However, in the 2016 session, the module leader monitored lecture attendance over a longer period; attendance monitoring began on the fourth teaching week and continued to the 11th week of the module. Monitoring lecture attendance over the longer period in the 2016 session allowed us to explore the potential impact of continual attendance/absence throughout the term and examine the extent to which attendance over the matched 3 weeks related to attendance over a longer period. The 2015 and 2016 matched attendance measure varied from 0 (no attendance) to 3 (full attendance) representing lecture attendance in teaching weeks 4 to 6 across both years. In the 2016 session, a correlation of 0.91 ($p < 0.001$) was found between the attendance measures of the 3-week and 8-week periods (see Table 2). This finding shows that the shorter (3-week) attendance measure seems to be highly representative of attendance patterns more generally, thus validating the use of the 3-week attendance measure when conducting analyses with 2-year combined sample.

Attainment measure The dependent variables used, as a measure of attainment, were final grade for the module and exam grade. Exam grade was used due to the high level of lecture capture use during the revision period prior to the exam assessment. Final grade was composed of four weighted elements, which were quizzes, participation, coursework and the exam. All attainment variables were downloaded from the university's student records database.

Quizzes: Each week (from teaching week 2 to 11), a 10-question (multiple choice) quiz was posted and open to the students to complete for a 12-h period, and the best eight answers contributed to 10% of the final grade.
Participation: Eight workshops were run from week 3 to week 11 and the student's participation in each of these was scored as 0 for non-participation and 1 for active participation. These eight scores were combined to contribute to 10% of the final grade.
Coursework: A thousand-word (20% weighted) coursework assignment was taken in during the seventh teaching week of term. This required the students to analyse a dataset provided and produce a report that answered questions linked to their data analysis.
Exam: A 90-min (60% weighted) exam was set that students had to take in the second week of January following the course completion. Thus, the students had approximately a month for revision.
Control variables: Two key variables were included in the analyses in order to control for their possible impact on grades in the regression analysis; these were *gender* and *average*

year 1 grade. The year 1 grade involved the average of eight first year 15-credit modules (all of which were compulsory).

Results

Bivariate relationships

A table of means, standard deviations and zero-order correlations between all of the study variables for the pooled sample dataset is presented in Table 1. Table 2 presents the same information for the two cohort datasets separately, along with *t* tests comparing means of the two cohorts. The relationships between key variables in the pre-lecture capture year are presented in the 'above-diagonal' of Table 2 and relationships in the post-lecture capture year are presented in the 'sub-diagonal'.

Briefly summarising bivariate relationships linked to the study's hypotheses, within the pooled data, we find a significant positive relationship between attendance and final grade on the module ($r = 0.416$, $p < 0.001$); this significant positive relationship was found between attendance and all four aspects of the module's assessment. This association between attendance and final grade is observed in both years, both before lecture capture ($r = 0.340$, $p < 0.001$) and after its introduction ($r = 0.469$, $p < 0.001$). Thus, students who attended more than others tend to score more highly across the module's assessments, supporting hypothesis 3a.

We compared the means of the two cohorts across the attendance and attainment measures (see Table 2). The pre-lecture capture cohort showed significantly greater average attendance in the matched 3 weeks of lectures (pre- versus post-lecture capture cohort means of 1.58 versus 1.19; $t(319) = 3.12$, $p < 0.01$) and significantly higher coursework grades (pre- versus post-lecture cohort means of 62.82 versus 58.28; $t(319) = 3.56$, $p < 0.001$). There were no significant differences between pre- versus post-lecture cohort means for year 1 grade, quiz grade, participation grade, exam grade or final grade.

In the most part, lecture capture usage did not show significant relationships with other measures collected; however, within-term lecture capture viewing was positively related to coursework grade ($r = 0.185$, $p < 0.05$) and weeks 4 to 11 lecture attendance ($r = 0.178$, $p < 0.05$). Thus, there was a tendency for the people who attend lectures to also view lecture captures during the term; these people also tended to do slightly better at the in-term coursework. The correlations between module-end lecture capture use with the 3-week attendance ($r = 0.128$, $p > 0.05$) and the 8-week lecture attendance ($r = 0.155$, $p > 0.05$) measures as well as final grade ($r = 0.096$, $p > 0.05$) were all non-significant.

In terms of significant correlations involving the control variables, a significant positive relationship was found between year 1 grade and attendance ($r = 0.262$, $p < 0.001$). There were also significant positive relationships between year 1 grade and all attainment indicators over the 2 years ($r =$ between 0.362 and 0.562, $p < 001$). These results show that students who did well in the previous year tended to attend more and achieve greater attainment than those who performed less well in their first year of study. In the pooled data, females score higher on weekly quizzes than males across the 2 years. The results in Table 2 show that gender is positively related to other elements of assessment grade in the first year; females do better at the quiz and participation and get higher final grades before lecture capture is introduced; however, these relationships fall from significance after lecture capture is introduced.

Table 1 Correlations between all variables, pooled sample both years

†	1†	2	3	4	5	6	7	8	Mean	S.D.
1. Year 1 grade									65.36	9.57
2. Attendance weeks 4, 5, 6	0.262***								1.38	1.14
3. Grade coursework	0.469***	0.273***							60.55	11.52
4. Grade weekly quiz	0.520***	0.379***	0.471***						67.86	19.06
5. Grade participation	0.362***	0.452***	0.377***	0.564***					84.09	21.53
6. Grade exam	0.562***	0.310***	0.413***	0.432***	0.414***				58.00	13.56
7. Final grade	0.637***	0.416***	0.633***	0.663***	0.641***	0.927***			62.10	11.65
8. Gender (M = 1; F = 2)	0.028	0.115*	0.034	0.148**	0.098	0.022	0.065		1.55	0.50
9. Lecture capture availability year (1, 2)	0.104	− 0.172**	− 0.197***	0.097	− 0.105	− 0.041	−0.071	0.041	1.50	0.50

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

† $N = 321$

Table 2 Correlations between all variables, before lecture capture (above-diagonal) and after lecture capture (sub-diagonal)

	1	2	3	4	5	6	7	8	9	10	Mean Y2	S.D. Y2	Mean Y1	S.D. Y1	*t* stat
1. Year 1 grade		0.293***	0.528***	0.534***	0.322***	.560***	0.630***	0.109	–	–	66.36	9.25	64.37	9.80	$t(319) = 1.87^{\dagger}$
2. Attendance weeks 4/5/6	0.280***		0.173*	0.386***	0.393***	0.253**	0.340***	0.216**	–	–	1.19	1.18	1.58	1.06	$t(319) = 3.12^{**}$
3. Grade coursework	0.475***	0.319***		0.539***	0.351***	0.455***	0.663***	0.056	–	–	58.28	11.15	62.82	11.48	$t(319) = 3.56^{***}$
4. Grade quizzes	0.500***	0.418***	0.471***		0.595***	0.574***	0.767***	0.261**	–	–	69.72	19.98	66.01	17.98	$t(319) = 1.75^{\dagger}$
5. Grade participation	0.432***	0.485***	0.379***	0.568***		0.403***	0.624***	0.196*	–	–	81.82	22.15	86.34	20.73	$t(319) = 1.89^{\dagger}$
6. Grade exam	0.585***	0.350**	0.380***	0.334***	0.421***		0.931***	0.097	–	–	57.44	14.61	58.54	12.44	$t(313) = 0.72$ NS
7. Final grade	0.672***	0.469***	0.606***	0.597***	0.651***	0.926***		0.159*	–	–	62.28	12.11	62.93	11.15	$t(313) = 1.27$ NS
8. Gender	−0.067	0.040	0.030	0.039	0.015	−0.039	−0.013		–	–	1.58	0.50	1.53	0.50	
9. LC views in-term	0.063	$0.134^{\dagger}$	0.185*	0.075	0.018	0.111	0.130	$0.145^{\dagger}$		–	1.49	3.38			
10. LC views total	0.035	0.128	0.096	0.047	0.024	0.092	0.096	$0.145^{\dagger}$	0.639***		4.56	6.41			
11. Attend weeks 4–12	0.334***	0.906***	0.336***	0.426***	0.493***	0.383***	0.500***	0.037	0.178*	$0.155^{\dagger}$	2.69	2.64			

Above-diagonal $N = 161$; sub-diagonal $N = 160$

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$, $^{\dagger}p < 0.10$

Predicting attendance (dual-cohort analysis Table 3)

A hierarchical regression model predicting lecture attendance (the matched 3 weeks), using average year 1 grade and gender as independent variables, was significant $f(2,318) = 13.83$, $p < 0.001$, and accounted for 8% of the variance in attendance (R-square = 0.080). Adding the lecture capture availability year dummy improved the model significantly, $f(3,317) = 14.66$, $p < 0.001$, which now accounted for 11.4% of the variance in attendance (R-square = 0.114). Year 1 grade was positively related to attendance (beta = 0.280, $p < 0.001$) and in the pooled sample there was a gender effect (beta = 0.115, $p < 0.05$, males attended less than females). The lecture capture availability dummy accounted for a significant portion of variance and resulted in a significant negative beta (beta = − 0.206, $p < 0.001$), with attendance being lower after the introduction of lecture capture when accounting for gender and general academic ability. Thus, hypothesis 1 is supported.

To get a better understanding of the nature of the relationship between lecture capture availability and attendance, Fig. 1 presents the attendance patterns for the students across the 2 years before and after lecture capture availability. The proportion of the cohort who did not attend any of the three matched lectures rose from 19.9 to 39.4%, about the same proportion attended one lecture (26.1% before lecture capture introduction and 25% after introduction), fewer students attended two lectures (30.4% before lecture capture and 13.1% after) and about the same attended all three (23.6% before lecture capture and 22.5% after).

Predicting attainment (dual-cohort analysis Table 3)

The regression model predicting final grade attainment using average year 1 grade and gender as independent variables was significant, $f(2,318) = 109.64$, $p < 0.001$, and accounted for 41% of the variance in student attainment (R-square = 0.408). Adding the lecture capture availability year dummy significantly improved the model $f(3,317) = 79.00$, $p < 0.001$, which now accounted for 43% of the variance in student attainment (R-square = 0.428). The lecture capture availability year dummy was significant and negative (beta = − 0.141, $p < 0.01$)

Table 3 Attendance and attainment as a function of lecture capture availability (controlling for gender and year 1 grade); pooled sample

Independent variables	Dependent variables							
	Attendance Full sample	Attendance Full sample	Exam grade	Exam grade	Exam grade	Final grade	Final grade	Final grade
Year 1 grade	0.259***	0.280***	0.562***	0.572***	0.527***	0.636***	0.650***	0.582***
Gender	0.108*	0.115*	0.007	0.011	− 0.008	0.047	0.052	0.024
Lecture capture availability year		− 0.206***		− 0.101*	− 0.068		− 141**	− 0.091*
Attendance					0.161**			0.245***
R-square (and sig of change)	0.080***	0.114***	0.316***	0.326*	0.348**	0.408***	0.428***	0.481***
F	13.83*** (2318)	14.66*** (3317)	73.30*** (2318)	51.01* (3317)	42.24** (4316)	109.65*** (2318)	78.997** (3317)	73.13*** (4316)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, $N = 321$

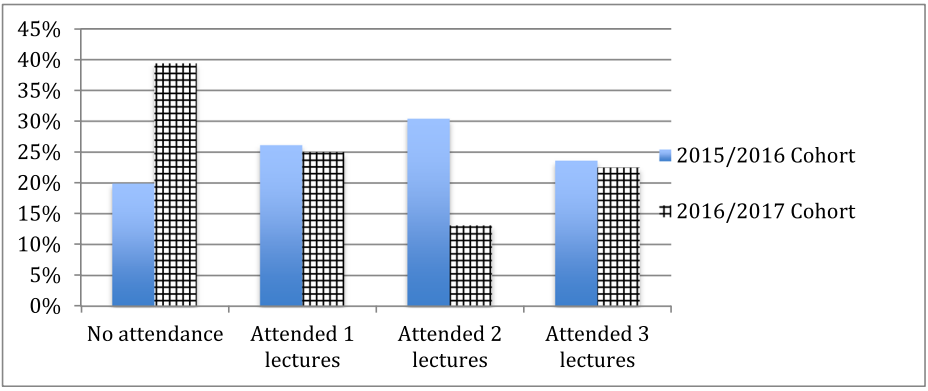

Fig. 1 Attendance in 3 matched weeks in years before and after lecture capture

suggesting that lecture capture introduction has a negative effect on overall attainment, over and above the effects of general academic ability. This supports hypothesis 3b.

Adding lecture attendance as an independent variable again significantly improved the model $f(4,316) = 73.13$, $p < 0.001$, which now accounted for 48% of the variance in student attainment (R-square = 0.481). Year 1 grade was strongly (positively) related to final grade on the module (beta = 0.582, $p < 0.001$), with no gender effect (beta = 0.024, NS); lecture attendance showed a significant positive relationship with attainment (beta = 0.245, $p < 0.001$); the addition of this measure accounted for an extra 6.5% of the variance in student grades. Thus, hypothesis 3a is supported. The lecture capture availability year remains significant and negative (beta = − 0.091, $p < 0.05$), suggesting that lecture capture introduction continues to have a negative effect on overall attainment over and above the impact of attendance.

The same analyses were conducted with exam grade as a dependent variable and the findings are largely the same as with final grade (with one small exception). Attendance showed a significant positive relationship with attainment (beta = 0.161, $p < 0.001$) and the addition of this measure accounted for an additional 3.2% of the variance in student exam grades. Although significant before adding attendance (beta = − 0.101, $p < 0.05$), the lecture capture availability year dummy was no longer significant once accounting for lecture attendance (beta = − 0.068, $p > 0.05$).

Mediation analysis

We assessed the mediation effect of lecture capture availability on attainment through attendance using the Process Macro (Hayes 2008). This calculates an indirect effect coefficient to represent the mediation using bias-corrected bootstrapped sampling. The analysis revealed a significant indirect effect through attendance in the relationship between lecture capture availability and final grade (beta = − 0.051, $p < 0.05$, LLCI = − 0.089:ULCI = − 0.022), which supports the proposed mediation and hypothesis 3c. A similar significant indirect effect is also found for exam grade (beta = − 0.033, $p < 0.05$, LLCI = − 0.069:ULCI = − 0.013), although as noted above within this model the effect of lecture capture availability becomes non-significant when attendance is accounted for, which suggests a more complete mediation. The resulting model is represented in Fig. 2.

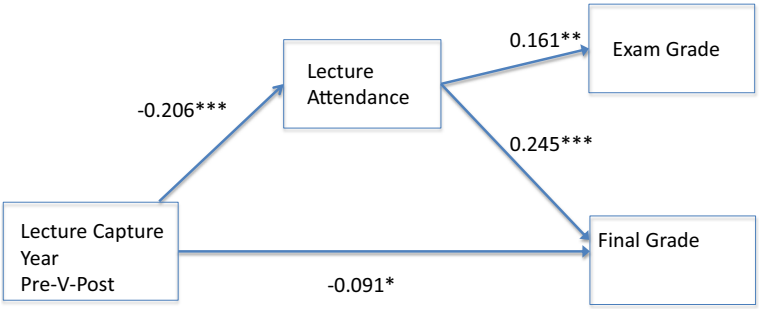

Fig. 2 Mediated model of the impact of lecture capture availability on attainment through attendance

Analyses incorporating lecture capture viewings

We tested the study's hypotheses that included an aspect of lecture capture usage with zero-order correlations and partial correlations for hypothesis 2 and regression analyses for hypotheses 4a/4b and 5 with the 2016 cohort. As mentioned above, the zero-order correlation between lecture capture viewings and lecture attendance post-lecture capture introduction was positive but non-significant ($r = 0.128$, NS); the partial correlation between lecture capture viewing and lecture attendance after accounting for our gender and year 1 grade (our controls) was also non-significant ($r = 0.115$, NS). Thus, hypotheses 2 was not supported. Two regression models were tested predicting both exam and final grades using average year 1 grade, gender, attendance of lectures over 3 weeks and total lecture capture views (including revision period) as independent variables. The full model predicting exam grade was significant ($F(4,154) = 23.97$, $p < 0.001$) and accounted for 38.2% of the variance in exam attainment (R-square = 0.382), see Table 4. The model predicting final grade was also significant ($F(4,154) = 45.62$, $p < 0.001$) and accounted for 52.9% of the variance in 2016/2017 student attainment (R-square = 0.586), see Table 4.

Adding lecture capture use showed no significant increase on the variance accounted for in attainment; thus, the spirit of hypothesis 4b is supported in that lecture capture use is not a

Table 4 Attainment as a function of lecture capture usage and attendance (controlling for gender and year 1 grade): post-lecture capture

Independent variables	Dependent variables					
	Exam grade 2016/2017	Exam grade 2016/2017	Exam grade 2016/2017	Final grade 2016/2017	Final grade 2016/2017	Final grade 2016/2017
Year 1 grade	0.585***	0.581***	0.525***	0.675***	0.668***	0.586***
Gender	0.001	−0.010	−0.019	0.032	0.020	0.007
Lecture capture use		0.073	0.054		0.085	0.052
Attendance (3 weeks)			0.196**			0.298***
R-square (and sig of change)	0.342***	0.347	0.382**	0.453***	0.460	0.529***
F (and sig of R-square change)	40.75*** (2157)	27.66 (3156)	23.97** (4155)	65.04*** (2157)	44.311 (3156)	45.619*** (4155)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, $N = 160$

predictor of attainment when controlling for ability. However, as the positive zero-order correlation between module-end lecture capture use and grade does not reach significance, the first part of this hypothesis is not supported (hypothesis 4a). Given the significant correlation between lecture capture usage and coursework grade, we ran a further regression using coursework grade as a dependent variable and found that after controlling for general academic ability, gender and attendance, lecture capture usage did not significantly predict coursework grade (beta = 0.051; $p > 0.05$). Therefore, we find no evidence that lecture capture usage has any unique effect on student attainment.

To test hypothesis 5, we ran a moderation test using Process (Hayes 2008); the two tests involved adding an interaction term (the multiplication of attendance and lecture capture usage) to the third and sixth model in Table 4. In both cases, the interaction term was non-significant (interaction-term beta = − 0.003, $p > 0.05$ predicting exam grade; beta = − 0.030, $p > 0.05$ predicting final grade). Thus hypotheses 5 is not supported.

Student behaviour profiles and attainment 2016/2017

To examine the lack of interaction between lecture capture usage and attendance in more detail, we grouped the students into three profiles of weeks 4–11 lecture attendance behaviours: a group that never attended lectures (30%), a group that attended between one and four lectures (41.9%), and one that attended more than 50% of lectures (28.1%). We combined our three categories of attendance behaviour with the three profiles of lecture capture views to explore the potential patterns of attainment across these different profiles. As Fig. 3 shows, the mean grade for the low-attendance/high lecture capture use group (mean = 63.77) is slightly higher than the low attendance/low or mid lecture capture use groups. Further examination

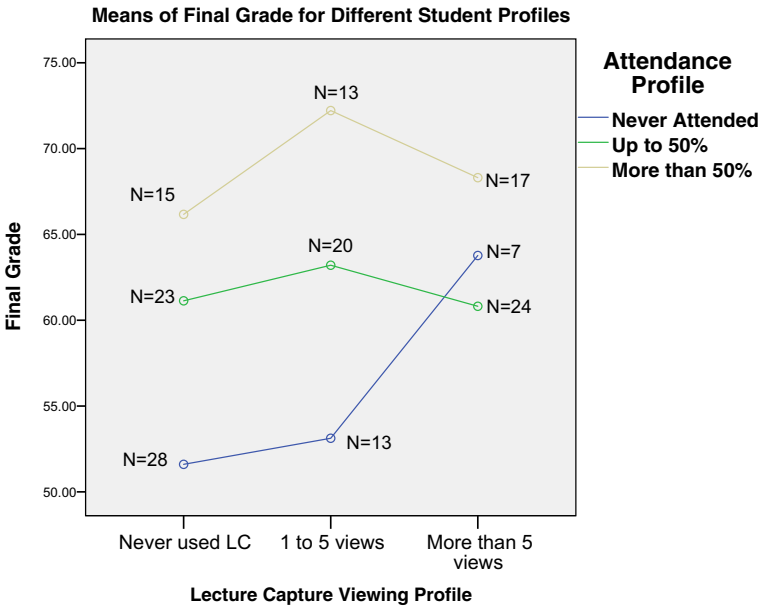

Fig. 3 Final grade associated with student profiles of attendance and lecture capture usage

showed that this group only had seven students in, three of which had mean final grades above 65 (71.4, 68.9, 67.8). The fact that only three students in the group showed high grades but very low attendance and high lecture capture use indicates that if lecture capture can help some students recover from non-attendance, these only represent a very small proportion of the cohort (under 2%). This perhaps explains why the moderation tests are not significant (despite the appearance of an interaction with Fig. 3).

Discussion

In a higher education setting where the use of lecture capture is becoming a normal and expected element of education delivery (Walker et al. 2014; Henderson 2014), we explore its impact on a core BSc module. Our investigation has a number of key findings that help us extend our knowledge of the impact of lecture capture on student engagement and attainment. Importantly, we distinguish between two features of lecture capture: its *availability* to students (not available versus available) and its *usage* by students (once available). These are often not recognised as meaningfully distinct factors within the literature, which, we suggest, contributes to the mixed set of findings that has emerged regarding the impact of lecture capture on student outcomes.

The top-level finding of the study is that the availability of lecture capture is associated with a drop in attendance (the number of complete non-attenders over 3 weeks of the module doubles to almost 40%) and ultimately student attainment. Importantly, the negative impact on attainment is mediated through its dramatic downward impact on attendance. The second central finding is that, whilst there is some evidence of a small significant positive relationship between lecture capture use and some aspects of attainment, for the most part the impact that lecture capture usage has on attainment is negligible, especially when general academic ability is controlled for.

Impact of lecture capture on attendance

Our findings support other research that has demonstrated certain outcomes associated with the availability of lecture capture (Holbrook and Dupont 2009; Traphagan et al. 2010). We show a drop in attendance following lecture capture introduction, even when we take into account general academic ability. Furthermore, we find that the lower level of attendance linked to the availability of lecture capture mediates its negative effect on attainment.

We also find that lecture capture usage has a negligible association with attendance. This suggests that students who use lecture capture more often are a mix of students who attend live lectures and those who do not. Furthermore, we note that attendance continues to have a negative impact on attainment even when lecture capture usage is taken into account; it is the contribution of lecture attendance on module attainment that seems more important than the effects of lecture capture usage in terms of main effects and interactive effects.

From looking at the pattern of change in attendance and comparing the matched lectures in the before and after analysis, a marked finding is the doubling of the number (and proportion) of students who are completely absent from lectures. When comparing the matched lectures, however, the proportion of students who show high lecture attendance does not seem to show much of a change; the big drop comes from those who attend some lectures rather than all. Our results based on objective data support other research findings that suggest that some students

self-report that the availability of lecture capture is likely to increase the likelihood of skipping lectures (Leadbeater et al. 2013). On aggregate, even if a minority of students think this, the introduction of lecture capture will lead to a drop in attendance and engagement across a cohort.

Impact of lecture capture on attainment

The finding that the availability of lecture capture is associated with a drop in attendance and lower grades supports a range of evidence presented in a number of other studies (e.g. Traphagan et al. 2010, who found a link between lecture capture availability and lower attendance, and Johnston et al. 2013, who found a link between lecture capture availability and lower attainment). Importantly, this deflationary effect of lecture capture introduction is found whilst controlling for previous average grades and gender which filters out any likely cohort and gender differences in attainment. It is worth emphasising that there is not a mean difference in grades across the two cohorts; thus, the significant relationship that we find when predicting grades with pre- versus post-cohort and attendance here suggests that the significant impact of lecture capture introduction is not due to a difference in cohort abilities (especially as we control for previous grade). Given the importance that attendance is known to have on attainment, if the introduction of lecture capture has a negative impact on grades, this is highly likely to flow through and have a negative impact on attainment so our findings are of no surprise here given the drastic drop in attendance that we witness after lecture capture introduction.

One of our key findings, which does not support other research, is that there is very little evidence of a positive relationship between lecture capture usage and attainment, suggesting that those who view lecture capture more do not receive higher grades. The only significant correlation is with coursework grade but even that relationship falls away when controlling for previous average grades, gender and attendance. Therefore, on an aggregate basis, we find that lecture capture usage itself will not necessarily help students increase their grades; students who are generally higher achievers who attend lectures are likely to get better grades regardless of their lecture capture usage; in contrast, students who do not attend are likely to get lower grades regardless of their lecture capture usage. Importantly, if it is the case that lecture capture availability might discourage a proportion of the cohort to skip lectures, they may never go on to recover their potential grades by using lecture capture.

Limitations and ideas for further research

A key strength of the study is that we explore attendance and attainment across the same module before and after lecture capture introduction where all aspects of the module setup are matched and we control for individual average grade for all students; thus, any cohort differences in ability should be filtered out of the analysis. However, the pre- versus post-lecture capture introduction differences in attendance could be linked to the fact that there might be unseen differences in characteristics of the two cohorts. We also need to recognise that although the current study may be representative of a typical quantitative research methods cohort in the UK, the impact of lecture capture may differ across taught subjects and institutional contexts and this may limit our ability to generalise to a broader base of students. It is possible that intrinsic motivation to study the topic and intellectual curiosity may differ across subjects which means the impact of lecture capture might be subject dependent (see

O'Callaghan et al. 2017). Another limitation is that we did not use raw lecture capture viewing time, as this was not available; we only used indices of where each students viewed more than 5% of a lecture.

Some of these limitations point towards ideas for further research. Here we use a before-and-after, between-subjects design. The stronger design would have utilised a both within and between design where four cohorts in the same year (no lecture capture to start then it is introduced; lecture capture to start then it is taken away; constant use of lecture capture; a no lecture capture control). There may naturally be situations across a university where these conditions occur. If these conditions could be identified and attendance records are taken as a norm, some very strong conclusions could be drawn about the impact of lecture capture introduction.

We further note one finding that we did not expect and that relates to the apparent differential effect of lecture capture availability across gender, namely that the negative effects of lecture capture availability on attendance and attainment may be more detrimental for females compared with males. We find that prior to lecture capture, females recorded superior attendance and attainment (in some assessments) than males (as shown by the positive correlations in Table 2), but these disappear after lecture capture becomes available. It is unclear why this may be the case and we do not have sufficient data to speculate too much further, but it would be worrying to consider that lecture capture may hamper any demographic group in particular. But this finding would certainly need to be explored in greater depth by future research before we can generalise.

Summary and conclusion

The introduction of lecture capture on a student cohort is likely to have many profound outcomes. In our study, its introduction appears to reduce attendance as lecture absence increases significantly following its introduction, and if we take lecture attendance as a key indicator of student engagement during the term, the introduction of lecture capture reduces engagement on an aggregate level. Importantly, students who skip a lecture will have to put more effort in to catch up later, and they may struggle to keep up with the content of the material during the term; not having face-to-face contact with instructors will mean that they cannot ask questions of clarification and they may fall behind. Lectures are used not only for helping deliver course content but they are a key touch point where information about assessment is transferred. Not being in the lecture can mean that some students approach an assessment deadline with less awareness of what is expected of them. In addition, the availability of lecture capture also potentially encourages some students to be less engaged during the term than they would otherwise have been without it (as lecture absence increases significantly following its introduction). Obviously, as indicated above, although the mean level of attendance drops, the proportion of students with high attendance levels does not drop; thus, if the introduction of lecture capture has an impact on attendance, its impact appears to be less with students who engage at a high level during the delivery term (potentially with those adopting a 'deep learning approach', Wiese and Newton 2013). Making lecture capture available will, however, be more likely to negatively affect less engaged students; potentially, students who utilise more of a 'surface learning approach' (those who may be more likely to cram at exam time) may be hit the hardest (in terms of grade). This is supported in the current study as the average final grade was not different across the years but the distribution of the

grades did differ across the 2 years, with the distribution of grades for the post-lecture capture cohort showing a greater spread than before lecture capture introduction.

Despite the findings in the current study that highlight the negative impact of lecture capture introduction on student attainment, students like having lecture capture available (see O'Callaghan et al. 2017). Lecture capture is also undoubtedly a heavily used tool for many students (it was viewed more than 700 times in this one module); therefore, once introduced, it is likely to be difficult to then take it away and it will be useful for many students. Recent work on innovative ways of using lecture capture towards a more integrated discipline-specific use is certainly worth considering further (Witton 2017). If lecture capture is to be utilised widely in a teaching environment, it is important to find ways to make the attendance of lectures hold value beyond their recorded substitute. One way of doing this is to ensure the experience that students get in a lecture is substantively different (and richer) than they would get from passively watching a recording. This may be through the encouragement of enhanced student interaction and/or participation during lectures or including small 'live' formative (or even summative) assessments during lectures.

Importantly, there is a strong case for clearly communicating to students the danger of an over-reliance on using recorded content and the potential negative impact that low lecture attendance could have on their attainment. In the majority of cases, students would not be able to use lecture capture to compensate for severe lecture absence using recorded content and the current study can serve as useful evidence to help educate students of the potential impact of low attendance; it is important to clearly communicate that the idea of binge-viewing lecture capture content during revision period can make up for severe absence is likely to be misguided.

References

Aldamen, H., Al-Esmail, R., & Hollindale, J. (2015). Does lecture capturing impact student performance and attendance in an introductory accounting course? *Accounting Education, 24*(4), 291–317.

Bosshardt, W., & Chiang, E. P. (2016). Targeting teaching lecture capture learning: do students perform better compared to face-to-face classes? *Southern Economic Journal, 82*(3), 1021–1038.

Brocato, J. (1989). How much does coming to class matter? Some evidence of class attendance and grade performance. *Educational Research Quarterly, 13*(3), 2–6.

Brooks, C., Erickson, J., Greer, J., & Gutwin, C. (2014). Modelling and quantifying the behaviours of students in lecture capture environments. *Computers and Education, 75*, 282–292.

Danielson, J., Preast, V., Bender, H., & Hassall, L. (2014). Is the effectiveness of lecture capture related to teaching approach or content type? *Computers & Education, 72*, 121–131.

Golding, J. M. (2011). The role of attendance in lecture classes: you can lead a horse to water. *Teaching of Psychology, 38*(1), 41–42.

Henderson, R. (2014). *Use of lecture capture within the Russell Group: who is using what, why and how it's going*. Oxford: UK.

Holbrook, J., & Dupont, C. (2009). Profcasts and class attendance—does year in program matter? *Bioscience Education*, 13(June). Available at: www.bioscience.heacademy.ac.uk/journal/vol13/beej-13-c2.pdf

Johnston, A. N. B., Massa, H., Burne, T. H. J., (2013). Digital lecture recording: A cautionary tale. *Nurse Education in Practice, 13*, 40–47.

Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2015). *NMC horizon report: 2015 higher Education Edition*. Austin: The New Media Consortium.

Karnad, A. (2013). Student use of recorded lectures: A report reviewing recent research into the use of lecture capture technology in higher education, and its impact on teaching methods and attendance. London School of Economics and Political Science, London. http://eprints.lse.ac.uk/50929/1/Karnad_Student_use_recorded_2013_author.pdf.

Kember, D., Jamieson, Q. W., Pomfret, M., & Wong. (1995). Learning approaches, study time and academic performance. *Higher Education, 29*(3), 329–343.

Leadbeater, W., Shuttleworth, T., Couperthwaite, J., & Nightingale, K. P. (2013). Evaluating the use and impact of lecture recording in undergraduates: evidence for distinct approaches by different groups of students. *Computers & Education, 61*, 185–192. https://doi.org/10.1016/j.compedu.2012.09.011.

Mallinson, D. J., & Baumann, Z. D. (2015). Lights, camera, learn: understanding the role of lecture capture in undergraduate education. *PS: Political Science & Politics, 48*(3), 478–482.

Marton, F., & Säljö, R. (1976). On qualitative differences in learning—I: outcome and process. *British Journal of Educational Psychology, 46*, 4–11.

Newman-Ford, L., Fitzgibbon, K., Lloyd, S., & Thomas, S. (2008). A large-scale investigation into the relationship between attendance and attainment: a study using an innovative, electronic attendance monitoring system. *Studies in Higher Education, 33*(6), 699–717.

O'Callaghan, F. V., Neumann, D. L., Jones, L., & Creed, P. A. (2017). The use of lecture recordings in higher education: a review of institutional, student, and lecturer issues. *Journal of Education and Information Technologies, 22*(1), 399–415.

Roberts, J. C. (2015). Evaluating the effectiveness of lecture capture: lessons learned from an undergraduate political research class. *Journal of Political Science Education, 11*(1), 45–60.

Traphagan, T., Kucsera, J. V., & Kishi, K. (2010). Impact of class lecture webcasting on attendance and learning. *Educational Technology Research and Development, 58*(1), 19–37.

Vajoczki, S., Watt, S., Marquis, N., Liao, R., & Vine, M. (2011). Students approach to learning and their use of lecture capture. *Journal of Educational Multimedia and Hypermedia, 20*(2), 195–214.

Walker, R., Voce, J., Nicholls, J., Swift, E., Ahmed, J., Horrigan, S., & Vincent, P. (2014). UCISA report: 2014 Survey of Technology Enhanced Learning for higher education in the UK, Oxford. Available at: http://www.ucisa.ac.uk/~/media/groups/dsdg/Tel 2014 Final 18 August.ashx

Wiese, C., & Newton, G. (2013). Use of lecture capture in undergraduate biological science education, *Canadian Journal for the Scholarship of Teaching and Learning*, 4(2), Article4.

Williams, A., Birch, E., & Hancock, P. (2012). The impact of online lecture recordings on student performance. *Australasian Journal of Educational Technology, 28*(2), 199–213.

Witthaus, G. & Robinson, C. (2015). Lecture capture literature review: a review of the literature from 2012 to 2015. Centre for Academic Practice. Loughborough University. Available at: http://www.lboro.ac.uk/services/cap/tel/tools/

Witton, G. (2017). The value of capture: taking an alternative approach to using lecture capture technologies for increased impact on student learning and engagement. *British Journal of Educational Technology, 48*(4), 1010–1019.