Lecture Recording in Mathematics and Physics: final report

Pamela Docherty, Toby Bailey, Ross Galloway,
Judy Hardy, Chris Sangwin, Anna Wood

February 2019

Executive Summary

In this project we investigate the impact of lecture recording on student learning in first-year Mathematics and Physics courses. We find that students watched recordings of lectures at a low rate (42% of students did not access the recordings at all) and for a short time (median viewing session is one-third to one-half of a lecture). Crucially, we find no evidence of a relationship between lecture recording use and attendance. In fact, students report that they prefer to attend lectures and cite a variety of reasons. We find that students see lecture recordings as just one of a number of study resources available to them, and they make strategic choices about what to use and when. The availability of lecture recording seems to support learning in live lectures by reducing the multi-tasking involved in note-taking and by providing a safety net for missed notes and for the occasional missed lecture.

1 Introduction

Across the UK higher education sector it is increasingly common for live lectures to be recorded and subsequently made available for students to watch in their own time [1]. Indeed many universities are investing heavily in this technology, installing lecture capture systems across lecture halls and teaching classrooms [2]. The drivers for this at the University of Edinburgh include supporting an increasingly diverse group of students and its perceived popularity with students. A number of potential benefits of lecture capture have been identified: it offers additional support for students whose first language is not English, and for disabled students [3, 4]; it gives students the flexibility to control their own learning [4], and the ability to juggle studying with work or caring responsibilities [5].

Staff concerns about lecture capture tend to focus on the impact it may have on attendance and learning outcomes. Although some studies report a drop in attendance [6, 7], others find no relationship [8, 9], and a review by O'Callaghan et al. concluded that overall there is little evidence that lecture capture availability leads to lower student attendance [10]. The effect of lecture capture on learning outcomes is also mixed: Hove and Corcoran [8] found that students with unlimited access to lecture captures earned higher grades than those whose access was restricted, and Williams et al. [11] found that students who attended lectures gained an additional benefit from supplementing their studying with lecture captures, but that students who used them as a replacement to lectures gained no benefit. However, Leadbeater et al. found no effect on grades [3].

There is evidence that the mixed findings in the literature are due to contextual factors, such as the subject area of the course, the teaching approach being used, the assessment regime, the backgrounds, ages, gender and learning beliefs of the students [12, 13]. One important factor affecting how lecture captures are used by students which is rarely discussed in detail is the learning environment in which these are experienced. This includes both the digital and the non-digital – the online resources that students have access to and the pedagogical approach of the lecture course that they are attending, and the way in which these influence each other.

An under-explored area of research is the investigation of the interplay between attitude to learning and the aforementioned factors of attainment and study behaviours. The past thirty years has seen the development of relatively reliable instruments to measure students' attitudes to learning such as the Approaches and Study Skills Inventory for Students (ASSIST) [14]. For example, [15] administered ASSIST to mathematics undergraduates across all year-groups and found the majority of students adopted strategic approaches to learning. In Physics, the Colorado Learning Attitudes about Science Survey (CLASS) [16] has gained much popularity. More recently, [17] adapted CLASS for use in a Mathematics context, producing the Mathematics Attitudes and Perceptions Survey (MAPS).

2 Method

This project's aim was to investigate the relationship between student engagement behaviours (namely lecture attendance and lecture recording usage), attainment (as measured by course mark) and approach to learning in first-year Mathematics and Physics courses. We also investigated to what extent the structure of teaching affects the above.

2.1 Research Questions

1. Do students with more effective learning beliefs and strategies use lecture recordings differently to those students with less effective beliefs and strategies?

2. Does the availability of lecture recordings affect attendance at live lectures? Does the amount of interactivity in live lectures affect this?

3. Does the structure of teaching (namely didactic or flipped) affect the way in which students engage with lecture recordings?

2.2 Methodology

2.2.1 Courses

Three courses formed the focus of this research: Two first year physics courses (Physics 1A, Mathematics for Physics 1) and one first year mathematics course (Introduction to Linear Algebra), all in Semester 1 of 2017/18.

Physics 1A (PHYS08016: P1A) has a typical class size of 270-320 students. Of these, approximately half will be students intending to complete a physics degree. The remainder are students on other degrees who are studying physics as an additional subject for typically one year. Most (but not all) will be on a STEM degree program.

Mathematics for Physics 1 (PHYS08035: MfP1) has a typical class size of 150-180 students, and all will be intending to complete a physics degree. The course is intended to provide a firm grounding in mathematical knowledge and techniques that will be needed for physics courses, and the mathematics is taught by physicists within a strong physics context.

Introduction to Linear Algebra (MATH08057: ILA) has a typical class size of 600 students. Of these, around 200 are intending to complete a mathematics degree or combined degree involving mathematics, around 250 are intending to complete an informatics degree and the remainder are from diverse degree programmes, both STEM and humanities.

We initially considered four further first-year courses in Semester 2 of 2017/18: Calculus and its Applications (MATH08058: Maths), Proofs and Problem Solving (MATH08059: Maths), Physics 1B (PHYS08017: Physics) and Mathematics for Physics 2 (PHYS08036: Physics). These were later discarded from analysis due to disruption from weather closures and industrial action.

2.2.2 Structure of Teaching

Physics 1A and ILA are taught in a flipped classroom format, which operate in the following weekly cycle. Course organisers identify resources (e.g. official textbook, other online resources) and the class is set clear targets for pre-class reading and preparation. The classes have three 50-minute sessions per week that are billed as 'lectures'; these take place in a traditional, raked lecture theatre with one instructor and no additional teaching assistants [18]. Note however, the expected pre-reading means students do not encounter material for the first time in these sessions. Instead lecture sessions focus on clarification, modelling problem solving, and active engagement episodes, primarily based around Peer Instruction [19]. Students answer questions during lectures using an electronic voting system (EVS). Students also attend a workshop session (90 min for ILA, 2 hours for P1A) each week, where class sizes are around 20 for ILA and 70 for P1A and the focus is on problem solving in small groups of 4-6 students.

In P1A and ILA, the digital resources provided to students are:

- A text-book and reading guide (ILA) and course handbook with online notes, containing more detail and links to simulations, external pages etc. (P1A).
- Lecture notes - that is, copies of what the lecturer writes during the lecture are scanned and uploaded.
- TopHat (EVS) quiz questions.
- Lecture recordings.

Mathematics for Physics 1 is taught in a non-flipped format. There are two 50-minute traditional lectures per week, in which the instructor introduces ideas and methods using lecture on the chalkboard. In addition, each student will attend two 2-hour workshop sessions each week as described above. Students are given 'Workbooks', which are akin to the Physics 1A course handbook, and scanned handwritten notes, problem sheets and solutions, including solved worked examples and lecture recordings (with chalkboard capture). As the lecturer writes on the chalkboard the only way to revisit this is through the lecture capture.

2.2.3 Data

Viewing data was obtained from the lecture recording platform Echo360 which records 30-second 'heartbeats' indicating that a recording is being played. Each heartbeat captured the date and time, student number and lecture number. Summing the heartbeats gives a total number of minutes watched per viewing session. Note that the heartbeats did not record the timepoint within the lecture recording that was being watched.

Attendance data for ILA and P1A were gathered using the TopHat electronic voting system. If a student voted in at least one question in a lecture, they were marked as being present. It should be noted that TopHat voting is not a perfect proxy for attendance: students could in theory vote when outside the lecture theatre and students may be present at the lecture but unable or unwilling to vote for various reasons. However, it is believed that both of these behaviours are rare. The latter is likely to be less common in ILA than P1A, as TopHat voting (engagement rather than correctness of answer) counts for a small proportion (5%) of the final course grade. ILA attendance data was also gathered from TopHat for the previous academic year. No attendance data was gathered for MfP1.

The Approaches and Study Skills Inventory for Students (ASSIST) questionnaire was administered to students in ILA and P1A during lectures in November 2017. An information sheet was provided to students and a video was shown which explained the project, what data would be collected and how students could exclude themselves from the study.

2.2.4 Student interviews

In-depth, semi-structured interviews were carried out with ten first-year students (5 female and 5 male) taking one or more of the three Semester 1 courses. Each student took at least one of P1A and ILA. Lecture capture usage data for the students was studied to decide which students to approach in order to ensure that we interviewed students with a range of lecture capture usage habits, including students who rarely used lecture captures. Student participants accessed a lecture capture between 0 and 19 times per course during Semester 1 out of a possible 33 lectures for P1A and ILA and 22 for MfP1. Interviews took place either by Skype or on the telephone and all were audio recorded and then transcribed professionally.

Ethical approval was sought and received through the Schools of Mathematics and Physics and Astronomy.

3 Results

3.1 Student interviews

The findings in this section form the preprint [20].Thematic analysis of the interview data was used to understand students' experiences of lecture capture and other digital resources such as lecture slides and notes. Their choice of resource depended on the affordances of the resource, the way in which information was presented in lectures and their beliefs about learning. The themes that emerged from the interviews are (1) supporting learning in live lectures and (2) personalisation of learning.

3.1.1 Supporting learning in live lectures

We found three sub-themes relating to learning in live lectures which indicated that:

1. students prefer to be in lectures and saw lecture captures as supplementing their attendance at live lectures;
2. the availability of digital resources ameliorated the need for multi-tasking in lectures, freeing up cognitive capacity for trying to understand the content;
3. the lecture captures were seen as a safety net, reducing the stress of having only one opportunity to hear the lecture.

Digital resources as supplementary to live lectures
Students showed consensus that they preferred to attend live lectures if possible and mentioned a range of advantages including: the opportunity to ask questions; social contact; social pressure to concentrate; getting out of their room, and the feeling that this was more of a 'real' experience compared to watching online. One common theme was that active-learning classes gave students experiences which would not be gained from watching the lecture online, such as discussing with other students.

> *I find it's just better to be there.... in physics we use TopHat, so there's some cases where we are asked to discuss answers to questions with people beside us, and obviously if you don't go to the lectures you miss out on that, and I think that's a really, actually quite valuable, that discussion. (Student 4)*

When students talked about using lecture captures it was commonly in the context of being as a supplement to lecture attendance. In doing this they took a targeted approach, listening only to the short section of the lecture capture that they needed, rather than watching the whole lecture from start to finish. Other digital resources, such as PowerPoint slides were also used in a similar way.

> *There's occasions where when I'm writing my own notes in the lecture cause I take just rough notes, I'll sort of underline and say, 'revisit recording' if I know there's something that I need to revisit. So I'll note that down while I'm in the physical lecture and then when I'm writing up my more formal notes when I see that in my rough notes, I might then go on to the lecture recording and skip through to the part where I know I need to revisit. (Student 1)*

Ameliorating multi-tasking in lectures
Although students preferred to be in lectures, they were also clear about the disadvantages of lectures and the way in which digital resources helped to ameliorate these difficulties. All students noted that there was a tension between taking notes and listening to what the lecturer was saying. Having to multi-task in this way made students feel that it was cognitively demanding to both to make notes and to listen to the lecturer effectively. This is perhaps particularly important in mathematics and physics, where understanding the flow of reasoning is critical to problem solving.

> *So when I'm writing down when I'm actually in the lectures I can't really listen to what else is happening because it's like multi tasking is sometimes difficult especially when it's like a hard physics problem or a maths problem. (Student 5)*

For some students the availability of slides or lecture notes meant that they didn't feel the need to make their own notes, and instead saw the ones that were provided as containing most of the information that they needed. It was however common for students to describe annotating those notes, adding more detail or clarifications.

> *And actually, because the slideshows are uploaded online sometimes I don't even take that many notes, because I know that that information is going to be accessible to me later, in a better form. So, sometimes it's actually a lot more useful for me to listen to what the lecturer is saying than to actually be frantically trying to copy down from a slideshow. (Student 4)*

For others, the availability of digital resources resulted in note-making being shifted from the lecture time to their own time:

> *In terms of studying generally like outside of the lecture, I'd probably look through the slides after, after the lecture itself with my notes and then write up proper notes. So like for each lecture I would go to the lecture and afterwards write up the notes while looking at the slides again. (Student 1)*

We note that in both cases the availability of digital resources changed the way in which students approach lectures, tending to spend less time making notes and more time listening to the lecture. We conclude that students were not just trying to avoid the effort involved in note-taking, but were actively choosing note-making strategies which they perceived would support them to learn.

Value of a safety net

While students preferred to attend live lectures, they also saw both lecture captures, and digital resources more generally as a safety net, which took away the stress of having only one opportunity to hear the lecture. Lecture captures were seen as a back up, enabling students to revisit material that they had not fully understood, or had not made sufficient notes on during the lecture.

> *It takes off the stress of having to panic about getting all the notes down that you need, or listening one hundred percent to the lecturer. (Student 2)*

Students also felt that simply knowing that lecture captures were available gave them peace of mind that they wouldn't miss out if something happened, such as illness or a family emergency that meant that they couldn't be at a lecture. This was expressed even by students who used lecture captures rarely.

Overall students seemed to view both lecture recordings and digital resources as something that could support their learning from live lectures, rather than as a substitute for attending the class. Digital resources were used strategically to help students who had missed something in a lecture and to reduce the demands of note-taking while listening to the lecturer, but were also seen as a safety net if they couldn't attend a live lecture.

3.1.2 Personalisation of learning

We found four sub-themes relating to learning in live lectures which indicated that:

1. the way in which the affordances of the digital resources affected resource choice;
2. the pedagogical approach of the lecture;
3. the way in which the flexibility of the digital resources enabled students to control the speed, and time of study;
4. students' beliefs about learning: a tendency to focus either on content acquisition or learning for understanding.

Affordances and choice of digital resources

Students were clearly aware of the different affordances offered by different types of digital resources, and would choose the resource which they felt best met their needs in a particular situation.

One aspect that influenced students' choice was the ease of accessibility of the resources. For example students noted that it could be more labour and time intensive to find the information they were looking for in a lecture recording compared to using digital slides.

> *I do also prefer making notes from slides, but I think that's just mainly because that's what I'm used to, and it's just a bit easier to just flick through a slideshow than to find a specific point in the lecture where he talks about this one thing. (Student 7)*

Students' choice also depended on what type of information they were looking for, for example lecture captures were a useful resource if students had missed an explanation during a lecture, or had not fully understood a concept and needed to revisit the material. In contrast slides or lecture notes were more useful for checking the accuracy of their notes, but may not contain the level of detail that was needed for them to be used alone.

> *It depends what I'm looking for, because sometimes I'll be looking to see if what I've written down is correct, and in that case I'll just be looking at what the lecturer's written down, or what's on the slide. But if it's something that I've put as a note, to listen to the lecture then I'll go back and I'll just be listening to them, and then after they've spoken or made their point then I'll write notes on it. But ideally I just, I have an aim, and it's either the notes or the listening that I'm doing and. . . generally split it into that. (Student 4)*

It was also common for students to seek out digital resources beyond those that were provided for them as part of the course, such as videos on YouTube and Khan Acadamy ("Khan Academy," 2018). These provided alternative explanations which supported understanding of difficult concepts.

> *I'd rather just go [to the lecture] and then if there's something I don't understand, rather than just hearing again, I'd find it otherwise, either in the book or in the lecture notes or google it. (Student 9)*

We conclude that students' choice of digital resource depended on the type of information they were looking for and how easy that information was to obtain from the resources available to them, but also that students were proactive in using the resources, or seeking out new ones which supported their learning.

Pedagogical approach of Lecture

As discussed above students used lecture recordings and digital resources to ameliorate the demands of having to both write notes and listen to the lecturer speaking. Students also described the difficulty of keeping up when there was a lot of new information in the lecture and that it was often necessary to re-visit material at a later date either through lecture capture or lecture notes. Students often illustrated this by contrasting their experience of lecture recordings in Maths for Physics, a non-flipped class in which content delivery took place during the lecture, rather than in pre-readings with their experiences in the flipped classes.

> *I used them for maths for physics quite a lot. Not so much for physics, and that's because I felt maths for physics, we took a lot of notes and it was more when I felt like my notes were wrong or I was confused, so I'd go back to the lecture recordings what she'd said. But physics, because the lectures were more question and answer, I didn't refer to them back so much. (Student 2)*

In general the students described using lecture capture for classes that were information dense, rather than ones where time was spent on problem solving. This broadly correlates with the pedagogical approach; non-flipped classes tended to involve more presentation of new material. However, the way in which material was presented in a lecture also seemed to have an impact on how useful students found lecture recordings.

Flexibility

Students appreciated the flexibility that digital resources and lecture capture in particular gave them to organise their own time. While overall students preferred to be in lectures, there were a number of circumstances where they made use of the option to watch the lecture recording instead of attending the lecture. Reasons for missing lectures included illness, accommodation viewings, attending family funerals and travelling to take part in sporting events. Many students also described occasions where the availability of lecture captures enabled them to juggle the demands of course work and lecture attendance. For these students the decision to watch lecture captures was strategic; lecture captures gave them control over the timing of their learning and were not being used as a quicker or easier option.

> *Sort of when it's inconvenient or when it clashes with something or if I had other deadlines then .....you can say, 'well today I really really need to finish this particular topic' And so just do that and then catch up on the lectures the next day or another time. (Student 1)*

Beliefs about learning

The discussions with students revealed two distinct approaches to learning which impacted on the way in which they used digital resources. These were: a) a focus on content acquisition and b) learning for understanding. Each individual student displayed either or both of these approaches depending on the circumstances.

When focussing on content acquisition students tended to view obtaining a good set of lecture notes as an important goal. In this mode students often saw lecture recordings as containing all of the 'information' that they needed, and being of equal value in this respect, to attending lectures in person (though there were other reasons why they preferred to be in the lectures). This focus on content acquisition could be seen in attitudes to lecture recordings of active learning classes, where problem solving was seen as less useful than lecturer explanations:

> *So I think the professor who gives this lecture spend a lot of time on the example questions instead of telling us the knowledge directly.... And I think that it*

[watching lecture recordings] is more efficient and just, and I can pause if I need more time to do and move fast forward to instead of wait for the other students to do. (Student 3)

Other students agreed with the idea that watching a lecture capture of a flipped class was quicker than attending the lecture. This was partly because they could fast forward through the peer-discussion sections, but also because they tended to skip over the quiz questions rather than to think about them themselves as they would have done in the live lecture. For these students digital resources were seen primarily as a source of good notes.

For some students learning was seen as a two step process involving initially content acquisition followed by understanding later. Here the process of writing notes was not seen as having any intrinsic value, and was only necessary in courses where digital notes were not provided:

I think there's like an extra step with maths for physics, I would say, because you need to write it out and then try and understand it. Whereas you can kind of skip the copying part that's almost slightly mindless, I would say. Like it's rote copying to have it down on paper. You can kind of skip that with physics and introduction to linear algebra whereas maths for physics you obviously have to copy out like word for word what's down if you want the information so I think that's probably the biggest difference. (Student 6)

These findings suggest that students' beliefs about learning affect the value that they place on obtaining a set of notes, and this in turn impacts the way in which they use digital resources to support their learning.

In summary theme 2 explored the ways in which students were able to control their learning through their choice of digital resources. We found that students saw lecture captures as just one of a range of digital resources that were available to them, and the choice of resource, and the way in which it was used was influenced by the way in which material was presented in the lecture, suggesting that the pedagogical approach has an impact, the desire to obtain a good set of notes, and their beliefs about learning.

3.2 Lecture attendance and lecture recording use

We note how little the recordings were used in the courses of interest (see Figure 1). The median number of minutes viewed per student were 0.5 (ILA), 8 (P1A) and 22 (MfP1) minutes out of 27 hours (ILA, P1A) or 18 hours (MfP1) of recording. Across the three courses, 403/951 (42%) students did not access the recordings at all. Taking only instances where students viewed a non-zero amount, the median length of viewing session is 13 (ILA), 13.5 (P1A) and 17 (MfP1) minutes (see Figure 2). The median number of minutes watched per lecture (with repeat viewings taken into account, where a student is watching the same lecture on more than one day) is 17 (ILA), 19 (P1A) and 26.5 (MfP1).

Attendance was collected in 30/33 (ILA) and 31/33 (P1A) lectures; the remaining lectures being introductory or revision lectures where no TopHat questions were posed. Mean attendance was 84% (ILA) and 59% (P1A) of total lectures. The difference in attendance between ILA and P1A may be explained by the fact that in ILA engagement (i.e. voting in TopHat questions) counts for 5% of the final course grade. Table 1 gives summary statistics for attendance and recording use for each of the courses. In Figure 3 we see that there is a slight negative correlation between

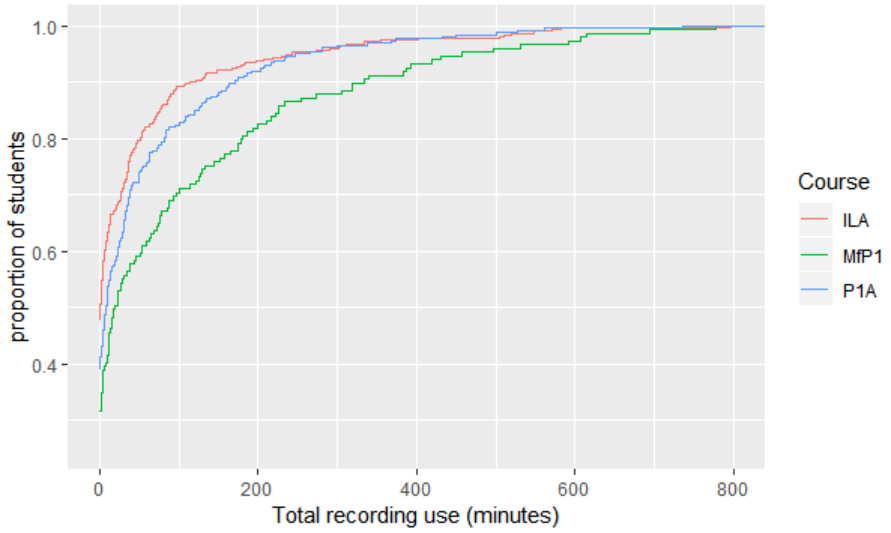

Figure 1: Cumulative distribution plot for recording use in minutes by course

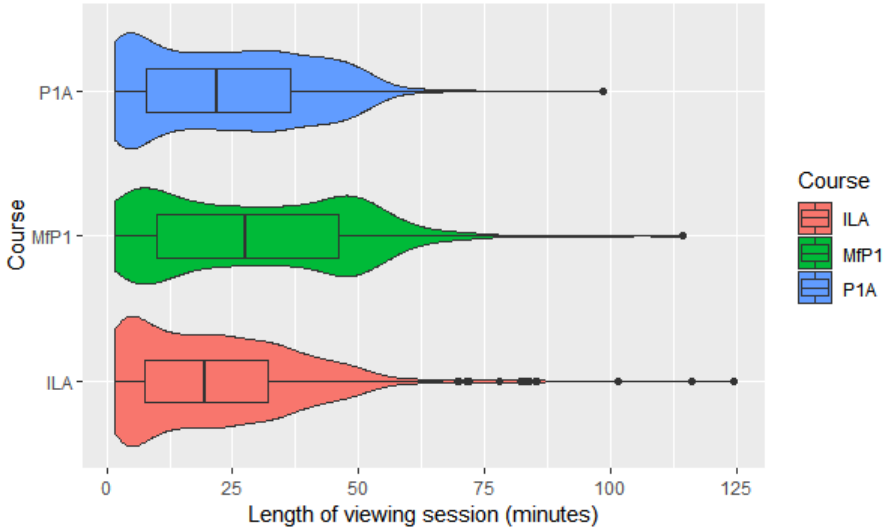

Figure 2: Violin and boxplot for length of viewing session in ILA, P1A and MfP1

number of lectures attended and total recording use, however, there is not enough data at the lower end to give any conclusive correlation.

In Table 2, we compare how much a student watched of a lecture recording and whether the student was present or absent at that lecture. Amongst instances where a student attended a lecture, in 95% (ILA) and 97% (P1A) of cases, the student watched 0-4 minutes. Where a student was absent, in 97% (ILA) and 82% (P1A) of cases they watched 0-4 minutes. In Table 3, we remove students who were deemed to have low engagement in the course overall (the measure being submitting fewer than half of online assignments). 23 (ILA) and 5 (P1A) students were removed. The figures in this case are the following. Amongst instances where a student attended a lecture, in 96% (ILA) and 97% (P1A) of cases, the student watched 0-4 minutes. Where a student was absent, in 82% (ILA) and 80% (P1A) of cases they watched 0-4 minutes.

In Mathematics for Physics 1, 83% of viewing opportunities were 0-4 minutes, 7% were 4-30 minutes and 10% were longer than 30 minutes. Note we do not have lecture attendance data.

Table 1: Descriptive statistics for attendance and recording data for ILA, P1A and MfP1

	n	Mean	SD	Range	Median
Attendance ILA (%)	536	0.84	0.26	0-1	0.93
Attendance P1A (%)	264	0.59	0.35	0-1	0.72
Recording use ILA (mins)	536	45.68	113.56	0-879	0.5
Recording use P1A (mins)	264	60.64	131.84	0-1025	8.25
Recording use MfP1 (mins)	151	111.42	187.22	0-1006.5	22

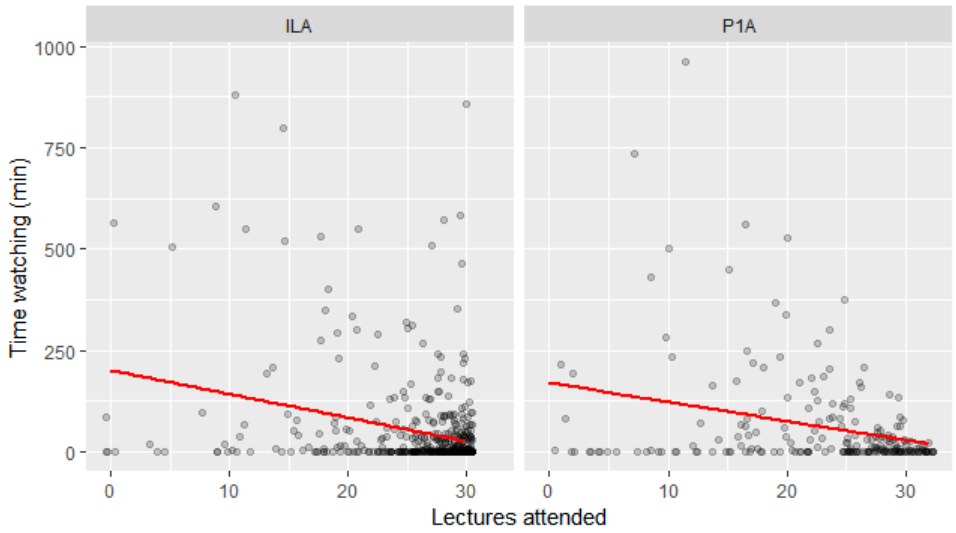

Figure 3: Scatterplot of number of lectures attended vs total recording usage (mins) for ILA and P1A

3.2.1 Viewings by date

The majority of viewings occur within a few days of the lecture taking place (see Figure 4). The number of minutes watched per day increases closer to the exam period for ILA and MfP but not for P1A (Figure 5).

3.2.2 Repeated viewings

In 77% of cases where a student watched a recording, they watched it on one occasion only.

3.2.3 Comparison with previous year

We compare attendance figures for ILA between 2016/17 and 2017/18. The course structure was identical in the two years except for the availability of lecture recording in 2017/18. A Wilcoxon rank sum test finds that average attendance was significantly higher in 2017/18 ($M = 0.894, SD = 0.274$) than in 2016/17 ($M = 0.831, SD = 0.254, Z = -3.69, p < .001$). We therefore see no evidence that the introduction of lecture recording leads to reduced attendance.

3.3 Approaches to Learning vs Lecture recording usage

The results from ASSIST were as follows: in Maths, 72% of students had a strategic approach to learning, 15% had a deep approach to learning and 13% had a surface approach to learning.

	ILA		P1A	
	Present	Absent	Present	Absent
n	13988	2302	4862	1866
0-4 mins	0.95	0.93	0.97	0.82
4-30 mins	0.03	0.04	0.02	0.09
30+ mins	0.02	0.03	0.01	0.09

Table 2: Attendance at lecture vs amount of recording watched for ILA and P1A

	ILA		P1A	
	Present	Absent	Present	Absent
n	13153	1487	4756	1644
0-4 mins	0.96	0.82	0.97	0.80
4-30 mins	0.03	0.11	0.02	0.10
30+ mins	0.01	0.07	0.01	0.10

Table 3: Attendance at lecture vs amount of recording watched for ILA and P1A with low-engagement students removed

In Physics, it was 64% strategic, 27% deep and 9% surface. 327/536 (61%) ILA students and 121/264 (46%) P1A students completed the survey either in lecture or online afterwards. Table 4 gives an attendance and recording usage breakdown by course and by "dominant approach to learning" (deep, strategic or surface). Kruskal-Wallis rank sum tests show no significance between dominant approach to learning and recording use for either course (ILA: $p = 0.129$, P1A: $p = 0.253$).

3.4 Attainment and lecture recording use

Figure 6 shows the distribution of final course marks in the three courses. We performed a multilinear regression with output variable final course mark and input variables attendance (number of lectures attended) and number of minutes viewed in the lecture recordings. In both ILA and P1A, a higher exam mark is associated with more lectures attended, but not with time spent watching recordings, and there is no significant interaction between lecture attendance and recording use, see Figure 7. For MfP1 a simple linear regression shows no significant correlation between final course mark and recording use.

			Attendance		Recording use	
	Approach to Learning	n	Mean	SD	Mean	SD
ILA	Deep	49	0.90	0.14	32.0	96.3
	Strategic	241	0.90	0.21	35.9	96.1
	Surface	37	0.91	0.17	37.1	73.3
P1A	Deep	37	0.68	0.29	85.3	169.9
	Strategic	75	0.72	0.33	51.9	94.6
	Surface	9	0.53	0.42	21.1	38.4

Table 4: Descriptive statistics for attendance and recording data for ILA and P1A faceted by Approach to Learning

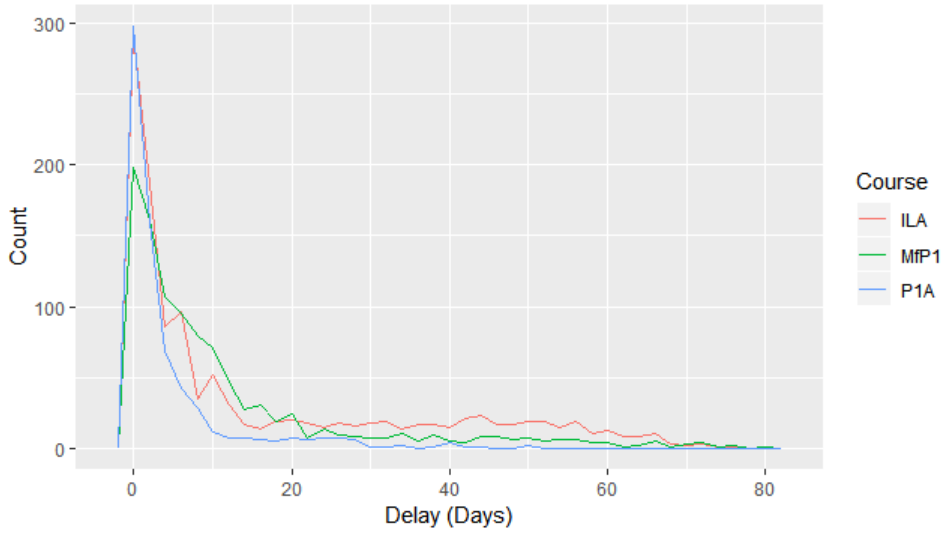

Figure 4: Delay in days between lecture taking place and viewing for courses ILA, MfP1 and P1A

3.5 Teaching format (flipped or didactic)

There was a significant difference in the recording use between the three courses ($F(2, 948) = 14.43, p < .001$). Comparisons using Bonferroni correction found that recording use was significantly higher in the didactic course MfP1 than the flipped courses ILA ($p < .001$) and P1A ($p < .001$) . However, with no lecture attendance data for MfP1 we could not make any conclusion regarding any difference in attendance between flipped and non-flipped courses. In Section 3.1 we propose that the difference in viewing patterns may be explained by the availability of other digital resources in ILA and P1A that students prefer to refer to.

4 Discussion

We note that guidance for students often focuses only on lecture capture use. Our findings here suggest that students integrate a range of different digital resources into their study practices and we therefore recommend developing guidance that encompasses the use of all digital resources as appropriate. Guidance should also be developed that is specific to the pedagogical approach of the lecture.

In line with others, we would not recommend using the lecture capture as a substitute for attending the live lectures, or watching the whole lecture capture for revision. Instead we recommend students attend the live lecture and use the recording to watch small chunks in a targeted approach e.g. if they need to clarify something that they have missed. We note that finding the relevant section of a capture can be time-consuming for students and therefore suggest that students note down the time in the lecture when they missed something, so that they can easily return to it.

Specific guidance for active learning lectures should involve encouraging students who have missed a class to 'play along at home' by thinking about the quiz question for themselves before listening to the lecturer's explanation and resist the temptation to fast forward. Students could also be encouraged to form study groups to discuss the questions, rather than watching the recordings alone. Students who have attended class could also benefit by returning to the lecture capture to test themselves with the quizzes, and particularly to think about their explanation

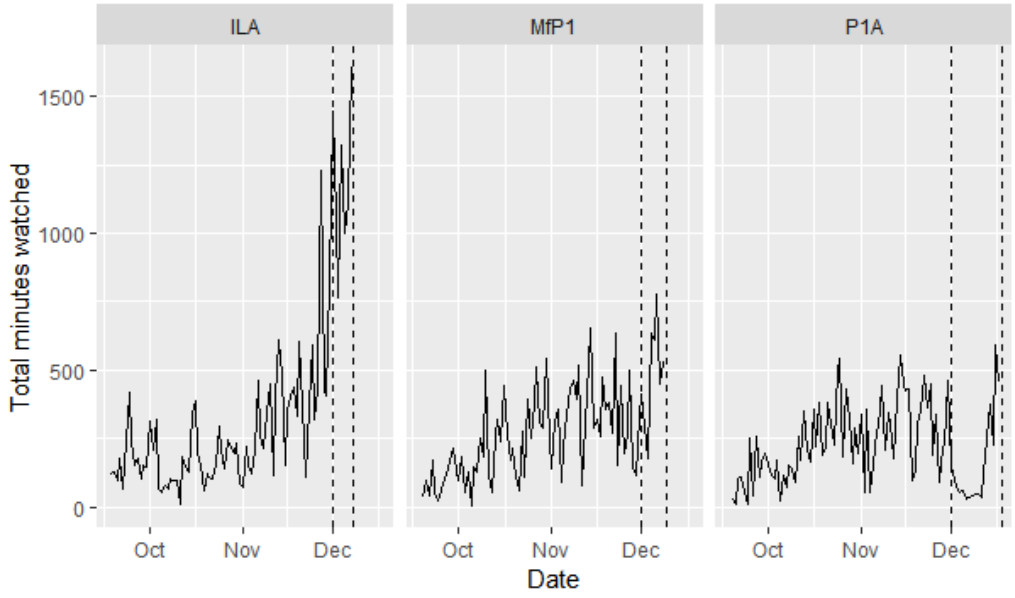

Figure 5: Line graph of total minutes watched by date. The dotted vertical lines indicate the revision period.

for the correct answer before it is revealed by the lecturer.

Guidance for the use of digital resources needs to be resource specific, but could involve encouraging students to annotate digital slides with more detail and with questions to consider, rather than focussing on making a complete new set of notes. Coupled to this we believe it is important for teaching staff to think about the digital resources that they are making available to their students and to reflect on the pedagogical reasons for that decision. They should also be aware of the ways in which different digital resources might be used, so that they will be in a position to encourage appropriate use of these resources in ways which support learning. We hope that the findings presented here will provide a useful starting point for this process. This project has generated interest elsewhere in the university and has resulted in a follow-up PTAS project[1] in collaboration with the Vet School along with SoM and SoPA. The project will investigate classroom practices within the three disciplines.

5 Acknowledgements

This project was supported by a grant from the University of Edinburgh Principal's Teaching Award Scheme. The team gratefully acknowledges input from Dr Mike Allerhand, Statistical Consultancy Unit, School of Mathematics.

[1] Classroom Practices and Lecture Recording

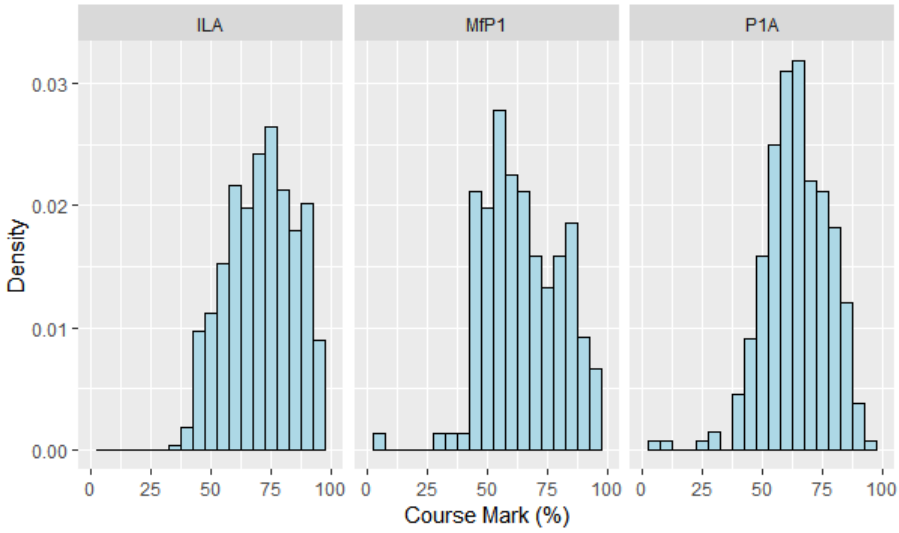

Figure 6: Histogram of exam marks in ILA, MfP1 and P1A

References

[1] John Couperthwaite, Juliet Hinrichsen, and Charles Shields. Modelling institutional approaches to web-based lecture technologies. *Curriculum, technology and transformation for an unknown future. Proceedings of Ascilite, Sydney*, pages 236–239, 2010.

[2] Emily Nordmann, Colin Calder, Paul Bishop, Amy Irwin, and Darren Comber. Turn up, tune in, don't drop out: {The} relationship between lecture attendance, use of lecture recordings, and achievement at different levels of study. 2017.

[3] Wendy Leadbeater, Tom Shuttleworth, John Couperthwaite, and Karl P Nightingale. Evaluating the use and impact of lecture recording in undergraduates: Evidence for distinct approaches by different groups of students. *Computers & Education*, 61:185–192, 2013.

[4] Jocasta Williams and Michael Fardon. Recording lectures and the impact on student attendance. *ALT-C, September*, pages 4–6, 2007.

[5] Michael Fardon. Internet streaming of lectures: A matter of style. In *Proceedings of Educause Australasia*. Citeseer, 2003.

[6] Martin R Edwards and Michael E Clinton. A study exploring the impact of lecture capture availability and lecture capture usage on student attendance and attainment. *Higher Education*, pages 1–19, 2018. doi: 10.1007/s10734-018-0275-9.

[7] Tomoko Traphagan, John V Kucsera, and Kyoko Kishi. Impact of class lecture webcasting on attendance and learning. *Educational technology research and development*, 58(1):19–37, 2010.

[8] M Christina Hove and Kevin J Corcoran. If you post it, will they come? Lecture availability in introductory psychology. *Teaching of Psychology*, 35(2):91–95, 2008.

[9] Luminica Topale. The strategic use of lecture recordings to facilitate an active and self-directed learning approach. *BMC medical education*, 16(1):201, 2016.

[10] Frances V O'Callaghan, David L Neumann, Liz Jones, and Peter A Creed. The use of lecture recordings in higher education: A review of institutional, student, and lecturer issues. *Education and Information Technologies*, 22(1):399–415, 2017.

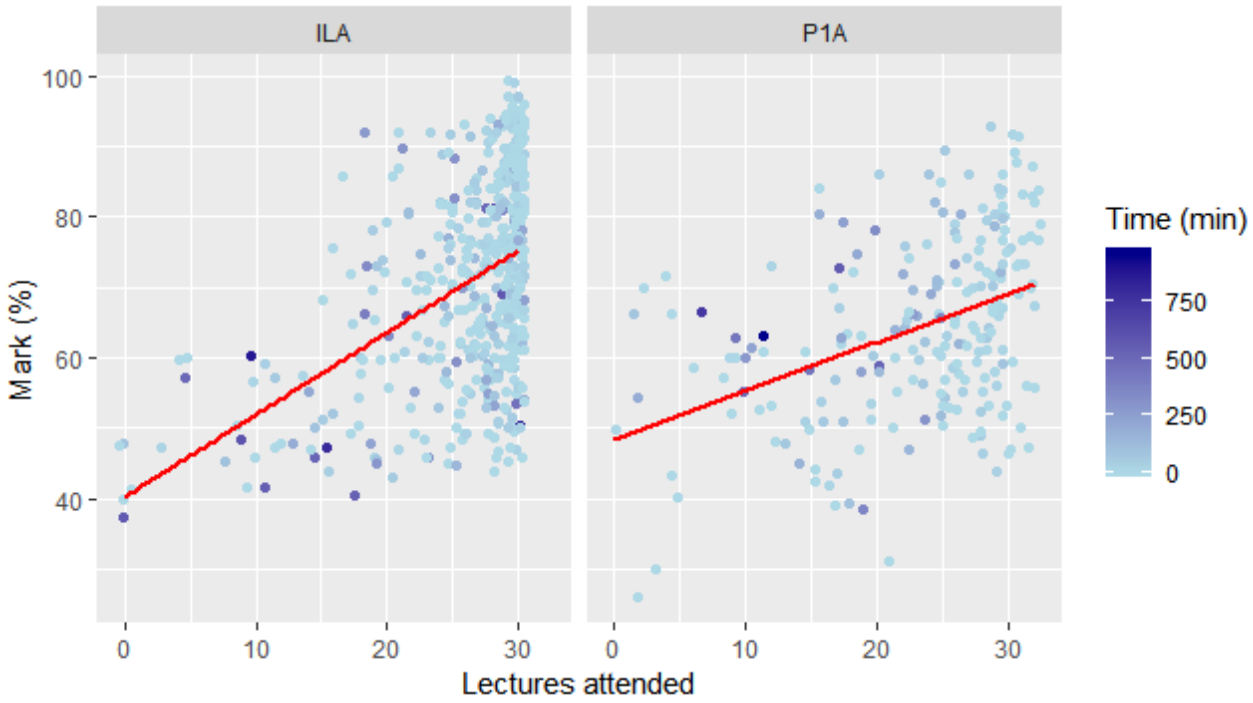

Figure 7: Scatterplot of attendance and final mark, coloured by total recording time watched

[11] Adrienne E. Williams, Nancy M. Aguilar-Roca, and Diane K. O'Dowd. Lecture capture podcasts: differential student use and performance in a large introductory course. *Educational Technology Research and Development*, 64(1):1–12, 2 2016. ISSN 1042-1629. doi: 10.1007/s11423-015-9406-5. URL http://link.springer.com/10.1007/s11423-015-9406-5.

[12] Gareth Hall and Antonia Ivaldi. A qualitative approach to understanding the role of lecture capture in student learning experiences. *Technology, Pedagogy and Education*, 26 (4):383–394, 2017.

[13] Martin O'Brien and Reetu Verma. How do first year students utilize different lecture resources? *Higher Education*, pages 1–18, 2018. doi: 10.1007/s10734-018-0250-5.

[14] Noel Entwistle, Don Skinner, Dorothy Entwistle, and Sandra Orr. Conceptions and beliefs about "good teaching": An integration of contrasting research areas. *Higher Education Research and Development*, 19(1):5–26, 2000. URL http://www.tandfonline.com/doi/abs/10.1080/07294360050020444.

[15] Eleanor Darlington. *Changes in mathematical culture for post-compulsory mathematicsstudents: the roles of questions and approaches to learning*. PhD thesis, University of Oxford, 2013.

[16] W K Adams, K K Perkins, N S Podolefsky, M Dubson, N D Finkelstein, and C E Wieman. New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey. *Physical Review Special Topics-Physics Education Research*, 2(1):10101, 2006.

[17] Warren Code, Sandra Merchant, Wes Maciejewski, Matthew Thomas, and Joseph Lo. The Mathematics Attitudes and Perceptions Survey: an instrument to assess expert-like views and dispositions among undergraduate mathematics students. *International Journal of*

Mathematical Education in Science and Technology, 47(6):917–937, 8 2016. ISSN 0020-739X. doi: 10.1080/0020739X.2015.1133854. URL http://www.tandfonline.com/doi/full/10.1080/0020739X.2015.1133854.

[18] Simon Bates and Ross Galloway. The inverted classroom in a large enrolment introductory physics course: a case study. In *Proc. HEA STEM Conf*, 2012. URL ftp://ftp.argila.com/Saddleback/2013Spring/CS1B/SupplementaryMaterials/Simon_Bates_Ross_Galloway.pdf.

[19] Eric Mazur. *Peer instruction: A user's manual*. AAPT, Prentice Hall, Upper Saddle River, NJ, 1999.

[20] Anna Wood, Toby Bailey, Ross Galloway, Judy Hardy, Chris Sangwin, and Pamela Docherty. Lecture capture as an element of the digital resource landscape - a qualitative study of flipped and non-flipped classrooms. doi: 10.31234/OSF.IO/824HV. URL https://psyarxiv.com/824hv/.