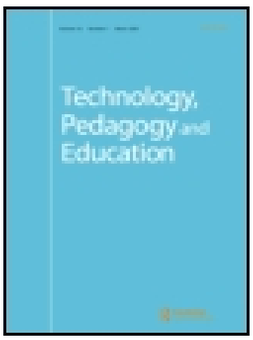
Lecture capture as an element of the digital resource landscape - a qualitative study of flipped and non–flipped classrooms



Technology, Pedagogy and Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rtpe20

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To cite this article: A. K. Wood, T. N. Bailey, R. K. Galloway, J. A. Hardy, C. J. Sangwin & P. J. Docherty (2021): Lecture capture as an element of the digital resource landscape - a qualitative study of flipped and non–flipped classrooms, Technology, Pedagogy and Education, DOI: 10.1080/1475939X.2021.1917449

To link to this article: https://doi.org/10.1080/1475939X.2021.1917449

Published online: 26 Apr 2021.

TECHNOLOGY, PEDAGOGY AND EDUCATION
https://doi.org/10.1080/1475939X.2021.1917449

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Lecture capture as an element of the digital resource landscape - a qualitative study of flipped and non–flipped classrooms

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ABSTRACT

While it is increasingly common for live lectures to be recorded and made available online, there has been little exploration of how lecture capture usage fits within the wider context of digital resources available to students. Here the authors report on in-depth semi-structured interviews with first-year students taking both flipped and non-flipped classes in mathematics and physics at the University of Edinburgh. Through thematic analysis two conceptual themes emerged: (a) Supporting learning in live lectures and (b) Self-customisation of learning. Students saw lecture capture as just one of a number of digital resources available to them, and their choice of resource depended on resource affordances, the way in which information was presented in lectures and their beliefs about learning. Digital resources seemed to support learning in lectures through reducing the multi-tasking involved in note-taking and by providing a safety net for missed notes. Implications for teaching practice are discussed.

ARTICLE HISTORY
Received 2 April 2019
Accepted 15 September 2020

KEYWORDS
Lecture capture; digital resources; flipped class; pedagogy; active learning

Introduction

It is increasingly common for live lectures to be recorded and subsequently made available for students to watch in their own time (Couperthwaite et al., 2010; Edwards & Clinton, 2018; Evans & Luke, 2020; Joseph-Richard et al., 2018; Leadbeater et al., 2013; Nordmann et al., 2019). Indeed, many universities are investing heavily in this technology, installing lecture capture systems across lecture halls and teaching classrooms (Nordmann & McGeorge, 2018). The drivers for this at the University of Edinburgh include supporting an increasingly diverse group of students and its perceived popularity with students.

While a major focus of lecture capture research has been its impact on attendance and learning outcomes, there has been much less work on understanding students' own experiences of using lecture captures. One important gap concerns how students integrate this technology with other resources available to them, particularly in technology-rich pedagogies such as the flipped classroom. Our aim in the current study is to use a qualitative, interview-based approach to give an in-depth exploration of students' views, attitudes and beliefs about the value of lecture capture for their learning. Our study departs from the current published literature by exploring these issues in the context of two aspects of the learning environment that have rarely been explicitly discussed: the digital resource landscape experienced by students and the pedagogical approach of the lecture. In this study students experienced two different types of classes: (a) flipped, active learning classes and (b) non-flipped classes.

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Research questions

The research is driven by two research questions:

(1) How do students experience lecture capture in relation to the wider digital resource landscape that is on offer?
(2) In what ways are students' experiences of lecture capture shaped by the pedagogic approach of the lecture?

Literature review

A number of potential benefits of lecture capture have been identified, although more work is needed in this area: it offers additional support for students whose first language is not English, and for disabled students (Dommett et al., 2019; Gillie et al., 2017; Leadbeater et al., 2013; Williams & Fardon, 2007; M. Williams et al., 2017); it gives students the flexibility to control their own learning (Hall & Ivaldi, 2017; Williams & Fardon, 2007) and the ability to juggle studying with work or caring responsibilities (Chang, 2007; Fardon, 2003) and can act as a safety net (Nordmann et al., 2019).

Staff concerns about lecture capture tend to focus on the impact it may have on attendance and learning outcomes (Joseph-Richard et al., 2018). Although some studies report a drop in attendance (Edwards & Clinton, 2018; Traphagan et al., 2010), others find no relationship (Hove & Corcoran, 2008; Topale, 2016), and a review by O'Callaghan et al. (2017) and work by Nordmann and McGeorge (2018) both conclude that overall there is little evidence that lecture capture availability leads to lower student attendance. The effect of lecture capture on learning outcomes is also mixed (Witthaus & Robinson, 2015): Hove and Corcoran (2008) found that students with unlimited access to lecture captures earned higher grades than those whose access was restricted, and A. Williams et al. (2012) 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. (2013) and Marchand et al. (2014) found no effect on grades. Saunders and Hutt (2015) found no improvement in grades for students who used lecture captures.

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, and the backgrounds, ages, gender and learning beliefs of the students (Hall & Ivaldi, 2017; O'Brien & Verma, 2018). 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. The aim of this article is to address this gap in the literature by exploring students' views of lecture capture in both flipped and non-flipped classes, with a particular focus on how resources are used by students.

Digital resources

Lecture captures do not exist in a vacuum: they are part of an increasingly complex digital landscape that students must navigate. While a few decades ago science students' only resources were a textbook and a live lecture, students may now have access to PowerPoint slides, quizzes, digital notes, online videos as well as both live lectures[1] and lecture captures. We use the term 'digital resources' here to refer to all resources available online which are used by students during their studies, whether or not they have been provided as part of the course materials. This includes lecture recordings, lecture notes and slides, quizzes (such as those used with Peer Instruction [Mazur, 1999]), digital textbooks, as well as external resources such as YouTube.

The wide range of digital resources available to students increases the opportunities for them to customise their study approach, which is thought to trigger higher motivation and better learning outcomes (Gross et al., 2016).

The literature suggests that students find some digital resources useful: McKenna and Kopittke (2018) found that on average 63% of science students downloaded lecture slides compared with 38% for lecture notes and only 16% for lecture recordings. O'Brien and Verma (2018) reported that most students used lecture notes in conjunction with either lecture captures or attending live lectures, while a significant minority used lecture notes alone, and a study of psychology students found that podcasts and vodcasts were seen as most useful when used in conjunction with lecture slides (Parson et al., 2009). Gillie et al. (2017) found that podcasts, key concept videos and solution videos were valued by students as both a tool for revision and a supplement to lectures. However, the literature on tool use, including lecture capture, indicates that students are not sure of how to maximise the learning benefits of online tools and that some students fail to make the most of these tools (Ellis et al., 2005; French & Kennedy, 2017; Lust et al., 2011). There is also some indication that the availability of PowerPoint slides can have a negative impact; for example, Traphagan et al. (2010) found that lecture capture led to lower attendance, but that the availability of course materials, such as PowerPoint slides or lecture notes, reduced attendance further. Parson et al. (2009) also noted that students might consider not attending lectures if they had access to PowerPoint slides but also found that students perceived that online resources were more beneficial in some lectures than in others, indicating that how digital resources are used depends on the context.

Lecture capture in the flipped classroom

The majority of lecture capture research focuses on lectures in which the exposition by the lecturer is very much the dominant form of instruction, rather than the active engagement methods which are normally associated with flipped classrooms. This may be in part because, particularly in the sciences, these types of lectures are still the most common form of teaching (Edwards et al., 2012; Stains et al., 2018). But there is also an underlying assumption that capturing other types of classes has little or no benefit. For example, Nordmann and McGeorge (2018) found that the majority of university policy statements on lecture capture explicitly addressed the issue that not all teaching activities were suitable for capture. However, in the sciences, particularly at first-year level, flipped, active learning classrooms are increasingly common, and in mathematics and physics at the University of Edinburgh they have been the norm for at least eight years. Flipped lectures are those in which students encounter the material through pre-class resources and spend time during the class in engagement with the content (Abeysekera & Dawson, 2015), for example, through discussions and problem solving. In physics at Edinburgh this involves spending approximately 50% of class time on conceptual questions that test students' understanding, voting using clickers (via the electronic voting system TopHat (2018)) and small-group discussions and 50% on the lecturer providing additional explanations and detailed answers to questions (Wood et al., 2016). The flipped classroom model is based on social constructivist theories of learning in which knowledge is believed to be actively constructed by the learner. To aid this process, the flipped classroom includes activities which are linked to greater cognitive engagement such as thinking, problem solving and discussing with peers (Chi & Wylie, 2014). Abeysekera and Dawson (2015) proposed that this approach results in better management of the cognitive load that students experience compared to lectures which predominantly involve the lecturer talking.

It is important to note that the pre-class resources are not necessarily videos, and in the classes investigated in this research students are provided with pre-reading consisting of textbooks and short online quizzes. However, the lecture capture phenomenon itself was catalysed by the recording of lectures to create pre-class videos for flipped classes. For this reason, the majority of the literature on flipped classes and lecture capture refers to the videos that are given to students as pre-

class resources (e.g. Missildine et al., 2013; Xiu et al., 2019); while our focus here is on the recording of live (flipped and non-flipped) classes which are subsequently made available to students.

Most lecture capture technology is predicated on the idea that lectures are primarily for content delivery, and indeed this technology has been criticised for reinforcing this model (Donnan et al., 2004). With the roll-out of lecture capture technologies there are pressing questions about how the pedagogical approach affects students' use of these resources and about the usefulness of lecture capture in classes which have an active learning approach.

Methodology

There have been a number of calls for in-depth research about experiences with lecture captures (e.g. Evans & Luke, 2020; Hall & Ivaldi, 2017; Karnad, 2013; Taplin et al., 2011). Qualitative methods are ideally placed for this type of research as they provide rich data for exploring students' experiences and insights of a phenomenon, yet they have been somewhat lacking in the lecture capture literature to date (Hall & Ivaldi, 2017). In particular, the way in which aspects of the learning environment, such as the pedagogical approach and the digital resources that are available, may impact on how students experience, think about and use lecture captures is rarely discussed in detail in the literature. Our approach in this current work is to explore these issues using semi-structured interviews which provide in-depth information about students' views and experiences.

The research was conducted through a realist framework and data analysis took a data-driven, inductive approach, which may be thought of as a 'bottom-up' approach where codes and subsequent theory are derived from the data itself without any preconceived ideas influencing the analysis (Thomas, 2003). A realist framework is useful here as it holds that knowledge is a social and historical product. Structures and mechanisms are seen as central to explaining our experiences of the world (Robson, 2002).

There is likely to be a complex interplay between the way that lecture captures are used, the resources available to students and the way that the material is taught. In order to reduce the number of variables and to control for disciplinary differences, this current work focuses on students in mathematics and physics, which have a similar focus on problem solving. The student participants in this study took standard courses from these departments which included those with a flipped, active learning approach and others which were not flipped. Many also took courses from other departments.

However, we should point out that the aim of this current work is not a rigorous comparison of lecture capture use in flipped classes and non-flipped classes (though that would be a worthwhile study). Instead our focus is on understanding lecture capture use within the learning environment experienced by first-year students in the Schools of Mathematics, and Physics and Astronomy which included both flipped and non-flipped classes. Nevertheless, as many of the classes being studied *are* flipped, the results do provide an insight into how students approach lecture capture use while experiencing different types of pedagogy.

Context

Lecture captures (termed 'lecture recordings' at the University of Edinburgh) consist of video recordings of the 50-minute live lecture which are subsequently uploaded to the web-based learning environment and made available to students. The captures typically show the chalkboard, the lecturer and a close-up of anything displayed on the audiovisual system, such as PowerPoint slides, clicker problems (electronic voting system questions) or written notes on a visualiser.

Three courses formed the focus of this research: two first-year physics courses (Physics 1A (P1A), Mathematics for Physics 1 and one first-year mathematics course (Introduction to Linear Algebra (ILA)), all of which took place during the first semester. Class sizes varied from 150 to 600 students.

Structure of teaching

Physics 1A and ILA are taught in a flipped classroom format in which students are expected to do pre-readings before the lecture, so that lecture sessions can focus on clarification, modelling problem solving and active engagement episodes, primarily based around peer instruction (Mazur, 1999) where students answer questions using clickers. Students also attend a workshop session (90 minutes 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 four to six students.

Mathematics for Physics 1 is taught in a non-flipped format. There are two 50-minute 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 workshops per week.

Students are provided with online and paper resources which encompass the material of the course (see Appendix for more details). None of the courses make any use of PowerPoint slides beyond occasional use for administrative announcements. However, we note that it was common for the students to refer to the experience of using lecture recordings featuring 'slides' or 'slideshows' in their interview responses. For the most part these will be recordings from other courses they are attending, which presumably do extensively use PowerPoint (almost certainly in unflipped mode). It is interesting that these experiences seem frequently to form the chosen counterpoint or contrast for the students when reflecting on their use of lecture recordings.

Participants

Semi-structured interviews were carried out with 10 first-year students (5 female and 5 male), determined to be sufficient to identify the majority of the key themes (Francis et al., 2010; Namey et al., 2016). Students took one or more of the three focus courses: Introduction to Linear Algebra (maths), Physics 1A (physics), Mathematics for Physics 1 (physics). Each student attended at least one of the flipped classes.

Purposive sampling (Devers & Frankel, 2000) was used in the following way: Students were initially asked to indicate whether they would be happy to be contacted for an interview during semester one. Lecture capture usage data for the students from this subset was then used 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 Mathematics for Physics 1. Interviews took place either by Skype or on the telephone and all were audio-recorded and then transcribed professionally. Students were asked about how, when and why they use lecture captures.

Ethical approval was sought and received through the School of Mathematics and the School of Physics and Astronomy: students were given an information sheet and interview questions prior to the interview and the purpose of the project, and their right to withdraw at any time and how their data would be stored and used was explained to them.

Data analysis

Thematic analysis was used to identify common ideas about the ways in which lecture capture was used by students. Although lecture captures were the focus of the interviews, all students discussed other digital resources in the course of their answers, therefore in the analysis attention was paid to all mentions of digital resources, including lecture captures. Analysis followed the six steps described by Braun and Clarke (2006). This involved familiarisation with the data and initial coding. Here the transcripts were checked against the audio recordings and read through a number of times in order to become familiar with the interviews. Relevant passages were highlighted and notes were made about the key ideas being expressed. Formal

coding was then carried out with NVivo. As the analysis progressed, data extracts and codes were discussed by the team of researchers, and themes, together with detailed descriptions of the themes, were developed. This process of negotiated co-coding (Lampert & Ervin-Tripp, 1993) involves all researchers debating an interpretation of the data until a common agreed understanding is reached. This helps to strength the dependability of the inferences drawn from the data (Bloomberg & Volpe, 2018). Throughout this stage the researchers returned to the data to check that the themes were representative of the interviews, so that themes were developed in an iterative process. Initial themes were further validated through discussions with colleagues across the University who have interests in lecture capture for teaching or pedagogical research.

Results

Here we report on the two themes related to students' use of lecture captures and other digital resources: (a) supporting learning in live lectures and (b) self-customisation of learning.

Theme 1: Supporting learning in live lectures

We found three sub-themes relating to learning in live lectures which indicated that: (a) students prefer to be in lectures and saw lecture captures and digital resources more generally as supplementing their attendance at live lectures, (b) the availability of digital resources ameliorated the need for multi-tasking in lectures, freeing up cognitive capacity for trying to understand the content, and (c) 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 Top-hat [clickers], 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)

Students also noted that lecture captures did not capture everything that took place in the lecture. In physics, the most commonly noted missing feature were demonstrations that were not captured by the cameras:

> Being able to watch a lecture online is great, but, for physics especially you can't see the demonstrations because they have them outside the [field of view of the camera]. (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 used in a similar way.

> There's occasions where when I'm writing my own notes in the lecture I'll underline and say, 'revisit recording' if I know there's something that I need to revisit . . . . 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 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)

Students discussed the way in which the availability of digital resources helped them to overcome these difficulties. In this regard students chose the digital resource which they felt best met their needs, whether this was lecture capture, lecture notes or slides.

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

> 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.

Theme 2: Self-customisation of learning

We found four sub-themes related to the way in which students made personal choices regarding the use of digital resources. These were: (a) the way in which the affordances of the digital resources affected resource choice, (b) the pedagogical approach of the lecture, (c) the way in which the flexibility of digital resources enabled students to control the speed, and time of study, and (d)

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 Academy (Khan Academy, 2018). These provided alternative explanations which supported understanding of difficult concepts.

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 the 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 revisit 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)

This implies that lecture recordings were used less frequently for the flipped classes P1A and ILA where more time was spent on quiz questions and discussions, and were seen as being more useful for Mathematics for Physics 1, a class which tended to be more information dense. The way in which information is presented also had an impact on lecture capture use: in Mathematics for Physics 1 the lecturer made heavy use of the chalkboard, which resulted in a lecture that for some students was

easier to follow and to keep up with in real time, compared to lectures which presented information in other formats.

> they kind of just bring up a slideshow and then just flick through it and talk. And, I find I need a lot more time to process the information from them talking and then all the information on the screen, and that's where it [lecture recordings] comes in really useful, whereas in maths it's more, it's a lot more natural and you can see the progression of everything very easily as she's writing everything on the chalk board as she's talking about it. (Student 4)

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. As well as being able to catch up on lectures when they had to miss them due to illness or caring responsibilities, students noted that another benefit of lecture captures was the ability to pause, rewind and replay sections of the lecture. This gave them the opportunity to skip over parts that they felt they already understood, as well as slowing down or replaying parts that they were struggling with. It was particularly useful for lectures that were information dense, as it gave students the chance to pause the recording to write notes as well as to take time to think about what they were learning:

> Sometimes I pause it because sometimes you have to write down stuff on the slide and the lecturer might go on to the next slide. So it's good to pause, you can understand what he said. Sometimes you want to rewind as well, yeah it's not just a stationary thing where you just let it go. I definitely interact as well. (Student 10)

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 focusing 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.

In other cases, students saw digital resources as important for developing their understanding of the material; they felt that returning to lecture captures in particular supported this:

> It's because it [lecture capture] kind of explains it in its basic form, and I think at the end of the day if you understand a principle or anything like that in its basic form then you can do more complicated versions of it, so it really does help. (Student 2)

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. 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. (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 customise 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, the desire to obtain a good set of notes and their beliefs about learning.

Discussion

The purpose of this study was to examine students' experiences of lecture capture within the context of the digital resource landscape and the pedagogical approach that they experienced. Broadly we found that students saw lecture captures as just one of a range of digital resources available to them, that they felt that digital resources supported their learning in live lectures and that the choice of resource depended on both personal and contextual factors.

Similar to other research (Hall & Ivaldi, 2017), students in this study saw value in attending the lecture over watching the recording at home. This study develops the existing literature by providing evidence that elements of an active learning pedagogy, such as opportunities for interactions with others, were seen as providing additional value compared to watching the lecture capture. This finding is relevant to one of the most common worries about lecture recordings – that students will stop coming to lectures if they can watch lecture captures instead. While the data in the literature is mixed (O'Callaghan et al., 2017), from our results it seems reasonable to conclude that if students feel that attendance at live lectures has some discernible additional benefit, then they will attend them rather than watch online.

The students in this study indicated that they used lecture captures and digital resources to supplement their learning from live lectures. While there is substantial evidence in the literature that students feel that they gain benefit from using lecture captures even when they have attended the lecture (Groen et al., 2016; Yoon et al., 2014), our findings show that this extends to the use of digital resources more generally. Students in our study used resources strategically to check details they had missed, either by referring to the slides or by rewatching short, targeted sections of the lecture. This is similar to Hall and Ivaldi (2017) finding that lecture captures are used strategically by students to control their own learning, but extends the current research by showing how students proactively choose the digital resources that best supported their needs. The choice of digital resource was linked to the type of information that the student was seeking as well as the ease with which it was possible to obtain that information from a given resource.

Both digital slides and lecture captures also provided students with a way to ameliorate the demands of multi-tasking by reducing the need to take notes in a lecture, with students either annotating lecture notes during the lecture, or using slides and/or lecture captures to generate formal notes after the lecture. While there is evidence that note-taking while listening to a lecture is beneficial (Kiewra, 1985; Titsworth & Kiewra, 2004), other research indicates that for complex material listening to the lecture may be better than taking notes (Kirby et al., 1999). However, research has also found that students who were given partial notes for lectures had higher achievement scores than students who had received complete notes (Annis, 1981; Russell et al., 1983). Similarly, guided

notes have been shown to improve achievement by increasing active engagement (Konrad et al., 2009). This literature indicates that making skeleton lecture notes available to students, particularly for lectures which cover complex material, and encouraging them to annotate them, may be more beneficial than providing complete lecture notes.

Students found that lecture captures were helpful for coping with the volume of material in the lecture, and they valued the flexibility that lecture captures gave them to pause, slow down or speed up the recording. We also noted that students more commonly described using lecture capture for classes that were information dense, rather than for ones where time was spent on problem solving. This broadly correlates with the pedagogical approach of the classes in the study; non-flipped lectures tended to involve more presentation of new material. This corroborates both qualitative and quantitative data in the literature which shows that students use lecture capturing to attenuate the cognitive demands of lectures (Hall & Ivaldi, 2017; McKinney et al., 2009). Our findings suggest lecture captures of flipped, active learning classes are used less frequently and students find them less valuable. This may reflect the different purposes of these classes: non-flipped lectures aim to communicate large quantities of information, making lecture recordings particularly valuable (Fardon, 2003), whereas flipped lectures generally focus on problem solving, as new material is introduced before the class. There is also evidence that the perceived difficulty of the topic results in higher lecture capture usage (Newton & McCunn, 2015). New material is more likely to be seen as difficult, and as non-flipped lectures consist entirely of new material, the lecture recordings of these classes may be seen as more beneficial.

However, this finding may also relate to students' beliefs about learning and the value of lecture capture. We found that some students focus on content acquisition and that this led them to viewing lecture captures as primarily a source of creating a good set of notes. Understanding the material was seen as something which happened only after good notes had been created. This may lead students to miss the potential role that lecture captures can have for developing deeper understanding. We note that students in this research did not mention any specific benefits of lecture captures of flipped classes. However, it is possible to envisage students gaining benefit from re-testing themselves with the quiz questions, with explanation generation and vicariously through emulating the lecturer's problem-solving strategies. More research is needed here to explore how students use lecture captures for these classes, and whether there could be additional benefits to using lecture capture for flipped classes which are currently being missed.

Implications for practice

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 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 focusing 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.

Conclusion

The focus of this article is an exploration of students' views, attitudes and beliefs about lecture capture. Our initial research question asked how students experience lecture captures in relation to the wider digital resource landscape that they have access to through their studies. Our findings indicate that students do not see lecture captures as sitting apart from the other resources and tools that they have access to, but instead are just one element of the digital resource landscape which is available to them. We found that students' use of digital resources is nuanced, contextual and strategic. Students choose resources which they feel will best support their learning, based on the ease of accessibility and the type of information they are looking for, their personal preferences and their beliefs about learning.

Our second research question focused on the ways in which the pedagogic approach of the lecture may be related to students' experiences of lecture capture. As discussed above, students found that lecture capture was just one of a range of digital resources that they used in their studies, so it wasn't always possible to separate students' experiences of lecture capture from that of the other digital resources that they used. We found however, that one key aspect driving students' choice of resources is the way in which information is presented in a lecture. Digital resources provide a way to ameliorate the demands of multi-tasking, for example, annotating slides reduces the need for taking notes during the lectures, and lecture captures enable students to catch up if something has been missed. These benefits were seen as particularly useful for lectures where the main aim is the presentation of new material and which are information dense. In general these are likely to be non-active learning classes rather than flipped, active learning classes where time is spent on problem solving. This raises further questions about how different styles of teaching affect the value of lecture captures. While we would not go as far as Fardon (2003), who concluded that lecture captures are more likely to be suited to disciplines such as the humanities and social sciences, we do call for further research to fully understand the potential benefits and potential pitfalls of lecture captures and digital resources more generally for active learning classes in the sciences.

By utilising a qualitative interview-based approach, we have provided rich data about the way in which students view both lecture captures and digital resources. We have added to the literature by exploring in detail the way in which students use these resources within both flipped and non-flipped classes, as well as highlighting how personal approaches to learning for different students impact on their resource choices.

Note

1. We use the term lectures here to denote a 50-minute time slot when a large group of students and a single teacher meet for the purpose of teaching and learning irrespective of teaching approach.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The authors are grateful to the University of Edinburgh Principle's Teaching Award Scheme (PTAS) for funding this research.

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Appendix Courses being studied

Physics 1A (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 programme.

Mathematics for Physics 1 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 (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.

Structure of teaching

For P1A nd ILA, each week, 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 (Bates & Galloway, 2012).

Digital Resources provided to students for P1A and ILA are:

(1) A textbook and reading guide (ILA) and course handbook with online notes, containing more detail and links to simulations, external pages etc. (P1A).
(2) Notes from the lecture (i.e. copies of what the lecturer writes on the visualiser (e.g. worked examples), scanned then uploaded). PowerPoint slides are rarely used.
(3) Clicker (electronic voting system) quiz questions.
(4) Lecture Captures.

Mathematics for Physics 1 is taught in a non-flipped format. There are two 50-minute 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.