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Investigating the 'When Viewed' Engagement with Lecture Capture Material of Accounting Students

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Keywords

Lecture capture; COVID-19; lecture recording; online; viewing; higher education; accounting.

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Abstract

Lecture Capture (LC) material is accepted to be an available and accessible resource for students in universities across the world. This exploratory study investigates the 'when viewing' LC material engagement of accounting undergraduate students. Three categories of engagement are defined, Near-Event-Viewing (NEV), Get-Round-to-Viewing (GRV) and Revision-Time-Viewing (RTV). The understanding of NEV, GRV and RTV, is tested by presenting different perspectives of how the categories are formulised. Comparative results on levels of engagement with LC material and impact on performance show differences between students across the different years of study. For example, for final year students, NEV of LC material has a noticeable positive impact on performance, compared with other viewing categories (GRV and RTV). The scale of these differences is also dependent on the considered perspective formulisation of the 'when viewing' LC material categories, acknowledging the caution necessary if/when universities formulise such 'when viewed' thinking on their available LC material.

1. Introduction

This study contributes to our understanding of how lecture capture (LC) material is used by students and whether this use impacts student learning outcomes. To achieve this, we address the following research question: 'When do students view LC and does it impact their learning?'. The need for this study was generated due to the seismic change of university learning environments in response to the COVID-19 pandemic. Universities around the world needed to increase their reliance on 'online' resources to allow students to continue their studies, while potentially having little understanding of how such changes impacted student learning. Further, as accounting requires a range of academic and vocational skills (Paisey and Paisey, 2007), research in other disciplines is not always generalisable and so requiring subject-specific investigations such as this study. A deeper understanding of how students use LC material will enable accounting educators to make informed choices and decisions about future blended learning environments and their efficacy.

We address our research question by constructing a range of categorisations identifying when students view LC material. This allows an exploration of student practices, where we further explore whether any association exists between assessment performance and when students engage with LC material. We find that depending on how students engage with LC material, learning outcomes, as

measured by performance, can be influenced. We further note that as students transition through their learning journey, their use of LC material may change suggesting the need for a more nuanced application of learning innovations.

As this paper is written, the world is progressing through a pandemic (Covid-19) which has tested academics ability to be flexible and reactive in their teaching styles and has required, for some, a paradigm shift to online learning in the university setting (see Williamson et al., 2020; Sangster et al., 2020). At the start of the pandemic, synchronous and asynchronous learning sessions became prominent to facilitate the completion of student learning and courses (see Amber et al., 2020), and continue to be used at this time to manage local outbreaks and rolling 'lock down' scenarios. However, this rapid shift restricted the opportunity for most academics to assess the impact of these learning environment transformations on their students. The efficacy of any innovation needs to be clearly understood before they are welcomed and become a 'norm' to avoid and limit unintended consequences. In the introduction to a book looking at emergence and innovation in digital learning, Veletsianos (2016) comments (p. 1x):

"Educational systems worldwide are facing enormous shifts as a result of sociocultural, political, economic, demographic, and technological changes. Emerging technologies (social media, serious games, adaptive software) and emerging practices (openness, user modeling) in particular, have been heralded as providing opportunities to transform education, learning, and teaching."

However, this emergence must be cautioned, where the same author purports (p. 1x):

"Yet, the ways that emerging innovations and practices are used in digital learning contexts are much more complex and elusive."

COVID-19 has reinforced the need to truly understand the use and relevance of e-learning, as the swift shift away from physical face-to-face teaching has raised a number of issues beyond that of IT infrastructure (Sangster et al., 2020). A blended approach may continue with us into the future, and so a clear understanding of how students engage and use e-learning is important to ensure that our teaching, and their learning, is impactful and relevant. Sangster et al. (2020) reflect on how accounting educators viewed the response of institutions in managing this rapid shift to online learning and raise several issues, including that at times, pedagogic needs have been ignored or curtailed due to pragmatism and most issues and conclusions were negative due to 'problems, challenges, bad experiences, and fear' (p. 437). This demonstrates the need to truly understand the use and impact by students of e-learning tools to assess whether learning has occurred (Dickson-Deane and Edwards, 2021).

We undertake an exploratory investigation of student engagement practices in using the popular e-learning innovation, lecture capture (LC), the recording or capturing of live face-to-face lectures which subsequently can be used as a learning resource by students (Banerjee, 2021). LC has been previously explored (see for example, Kushnir et al., 2011; Aldamen et al., 2015; O'Callaghan et al., 2017; Nordmann et al., 2019; Dommett et al., 2019; 2020; Ebbert & Dutke, 2020), investigating the use, perceptions and impact of LC material on both staff and students. From a recent review of the LC literature, Banerjee (2021) highlights that causative evidence is relatively limited and calls for research to understand the reality of LC (p. 1) and identifies that university students are self-regulated and self-paced and so their engagement behaviour is more difficult to predict or understand. Further, Fogarty (2020) specifically highlights the need to address the continued mysteries of student behaviour and actions as prior research is *'hampered by our primitive understanding of student motivation in normal times*' (p. 567). We contribute to this evolving literature by providing further insights into student engagement with LC material, through analysing in real-time, the use of LC material by students and their levels of engagement and its potential impact on performance.

This engagement knowledge is relevant to teaching and learning teams as no clear return to 'normality' can be seen in the near future and with the desire for some to embrace the opportunities and innovations that the pandemic has highlighted, LC is expected to remain as part of a blended-learning environment. However, as LC is a low-cost automated system compared to its predecessor of costly scripted televised solutions, it has been widely utilised but with little understanding or appreciation of its pedagogical approach or effectiveness (Brooks et al., 2014)

To explore the practices of students in terms of their use of LC, we address the following research question: 'When do students view LC and does it impact their learning?'. Groen et al. (2016) surveyed over a thousand students who identified various needs for LC, noticeably including, 'to pick up on things I missed while in class', 'as a back-up when I could not attend class' and 'to revise for exams', demonstrating perceived engagement behaviour of students regarding the 'when viewed' issue. Our exploratory study presents further insights, by defining and testing specific engagement categories across a single academic year and assessing the importance of when LC material is viewed by students (including first, second and final year students), relative to the lecture(s) they are associated with.

We define three 'when viewed' engagement categories, namely, Near-Event-Viewing (NEV) – viewing near to when the lecture took place, Get-Round-to-Viewing (GRV) – viewing sometime after the lecture took place and away from revision associated time and Revision-Time-Viewing (RTV) – viewing near to the relevant time of assessment (these are an adaption and development on the two-term categorisation given in Sarsfield and Conway, 2018). The three categorisations, NEV, GRV and

RTV are also viewed in respect to possible student, planned (GRV) and reaction (NEV and RTV) based usage of LC material, giving a greater insight into how students engage with LC. Moreover, whereas NEV and RTV can be seen as reaction-based engagement on the initial availability of LC material and impending associated assessment (exam), respectively, GRV in contrast is not reacting to connected events but may be more on a planned basis for the students and their learning activity.

To explore the appropriateness of our engagement categories (NEV, GRV and RTV), different perspectives on their formulisations are also considered. Different perspectives are considered to steer the study away from a presumed single 'universally accepted' position on interpreting/categorising when students view LC material (see Sarsfield and Conway, 2018). The reality is that to date, there is no 'universally accepted' notion of categorising students 'when viewed' engagement with LC material, and it is an acknowledgment that individual universities (and staff) may have their own view on such inference. The perspectives taken in this study include objective criteria-based thresholds between categories, as well as a university-defined threshold example.

To test the relevance of when students engage with LC material, we construct several measures relevant to student learning. These measures describe student levels of engagement in the form of actual minutes viewed of LC material and the percent of individual LC material viewed, and the performance of students in the form of a short-term mid academic year aggregated assessment mark and a long-term end of year final mark. Similar usage (Elliott and Neal, 2016; Sarsfield and Conway, 2018) and performance measures (Aldamen et al., 2015; Bos, et al., 2016; McCarthy et al., 2019) have been considered previously in relation to LC material, but to the authors' knowledge the use of both short- and long-term mark-based performance indicators is a further novel contribution of this study.

Our study contributes to the evolving LC literature by providing further insight into student behaviour. We achieve this by developing and testing various novel measures explicating student use of LC which can help practitioners and universities understand the impact of their technological innovations and interventions. This study also explores how student use of LC can impact on learning outcomes by investigating use and student performance.

The remainder of our paper is structured as follows: the literature review section summarises the need for subject specific investigations, specifically within the field of accounting, and provides an overview of recent studies addressing LC's impact on the learning environment. Next are two sections which discuss our data sources and then explains and derives the study's categorisations of when students view LC. Subsequently we present our findings and conclusions.

2. Literature review

LC has become increasingly popular with the integration of information technology into learning and teaching (L&T) and has generated a plethora of literature assessing the effectiveness of this innovation (Veletsianos, 2016; Morris et al., 2019; Banerjee, 2021). While the impact of LC on a range of issues has been explored within the extant literature, no consistent agreement on LC's effectiveness has been made (O'Callaghan et al., 2017; Morris et al., 2019). To contextualise our work and its contribution, a summary of recent studies and our focus on accounting as a discipline is presented to highlight the ongoing conflicting evidence present within the literature and to position our contribution.

2.1. The accounting discipline

Traditionally, accounting programmes have been vocational, training students in highly technical skills. However, there is a movement of change in that a more liberal approach has been recognised and championed to develop accounting education, identifying the need for a wider set of skills beyond technical compliance (Boyce et al., 2019; Herbert et al., 2021; de Villiers, 2010). Compared to other traditional subject areas, accounting education is more convoluted in that it is difficult to identify clearly its educational or pedagogic paradigm (Paisey and Paisey, 2007). This has yielded a search to understand how students learn accounting and their conceptions of learning. Byrne et al. (2010) conclude 'On the whole ... prior studies indicate that accounting students show no strong preference for any particular approach.' (p. 373). However, interventions impacting the learning environment of students have been seen to influence student approaches: for example, Abhayawansa et al. (2017) suggest that students' conceptions of learning can be developed (moving from a surface to deep approach) by incorporating high-level cognitive skills within the accounting curriculum. Conversely, case studies commonly employed to foster higher levels of learning (deep approach) have been found to be ineffective when used within accounting programmes (Ballentine et al., 2008; Wynn-Williams et al., 2016), demonstrating a need for discipline specific investigations of L&T innovations. Further, very little work has been undertaken on subject matter effects in online learning where course content is usually considered a constant (Arbaugh, 2005; Arbaugh et al., 2010). Prior research in other subjects cannot be generalised to accounting and in turn, individual subject-based investigations are needed.

2.2. Lecture capture (LC)

LC has become a common tool for supporting students as it is perceived to allow learners to take control of their own learning at a pace they feel comfortable with, while also supporting differing learning styles and needs (Dowling et al., 2003; Leadbeater et al., 2013; Elliott and Neal, 2016). The

literature has examined different dimensions of LC use and its subsequent impact on student learning. The following discussion summarises some of the recent studies addressing the impact LC can have when integrated into a learning environment, while also acknowledging the differential impact it may have according to the characteristics of students.

A common thread within the literature is the investigation of how LC is used as a potential substitute for attendance at live physical lectures. Learning and teaching staff are concerned that with the introduction of LC, student attendance will fall and have a negative impact on student learning. Dommeyer (2017) surveyed the literature on how LC has impacted student attendance and notes that of the 18 studies reviewed, only four confirmed that attendance fell with the introduction of LC. More recently, Morris et al. (2019) undertook a longitudinal study monitoring attendance at the start and end of a four-year period to 2017/18 and compared lectures which were captured and not captured by a LC system, overall, attendance was significantly higher if lectures were not captured. However, they do raise caution of such conclusions as students who are absent from lectures may not necessarily use LC.

Improving student outcomes is a focus for developing learning environments, and so a more pertinent question asked within the literature is 'how does the use of LC impact student performance?'. Nordmann et al. (2019) address this question by undertaking a study across four years of an undergraduate programme. They find that LC use and impact varies between cohort years: attendance and LC use have a positive impact on performance for first year students, but the significance of this finding reduced as students progressed through their studies. In addition, Nordmann et al. (2019) provide further insights by noting that non-native speakers used the recordings more significantly than native speakers. Other studies are inconclusive, such as Edwards and Clinton (2019) who by using a matched cohort, find that LC use has no correlation with performance if students attend lectures with LC failing to compensate for lower attendance. Bos et al. (2016) noted from their study that LC was frequently used as a substitute for lecture attendance and when doing so, was only effective in developing surface learning and not higher-order thinking skills.

Other studies have sought an understanding of LC use by surveying users. Dommett et al. (2020) found LC use was not homogenous across students, with LC being utilised more by lowerperforming students and those with greater contact hours. Ebbert and Dutke (2020), using selfreported data, identified clusters of students who exhibited a hierarchical structure of usage: from those who used the recordings as a substitute for lecture attendance to those who used LC material as a supplement to their learning. Different student clusters exhibited different learning goals, in turn impacting their LC use.

Studies within the accounting discipline, support the general literature that LC aids student achievement and learning, specifically when used as part of a blended learning environment (Aldamen et al., 2015; Dowling et al., 2003; McCarthy et al., 2019; Potter and Johnston, 2006). However, previous studies with a primary focus on LC and its impact on student behaviour within accounting is limited, with two exceptions: Aldamen et al. (2015) and de Castro et al. (2021). Aldamen et al. (2015) investigate the impact of LC on student performance and attendance within an introductory accounting course at a University in Qatar. The authors find a weak positive relationship between LC and student achievement, but the scope of this result is limited as they measure LC engagement as the total number of attempts a student made to view lectures with little insight into real-time use. De Castro et al. (2021), as part of a wider learner engagement study, found that the use of LC material has a positive impact on performance. However, this result does not hold for all categories of students. Specifically, LC use had a significant impact on international versus domestic students.

As noted above, the literature, although plentiful, is conflicted and demonstrates that student characteristics and engagement behaviour are important elements of understanding the impact of LC. Our work presented within this paper contributes further to this discussion by presenting additional insight into how students engage with LC.

3. Lecture Capture (LC) system and data

Data for this study is sourced from a single UK Business School offering a range of programmes in the general field of management, including the broad accounting subject area. With recent events such as the global pandemic, the single academic year of 2018-2019 is considered (including students in their first, second and final years of study), where to the best knowledge of the authors, there was no disturbance with an overall impact.

3.1 Lecture capture system

Lectures in the reference business school are captured by a university wide LC system, where teaching and learning sessions are recorded using a range of different peripherals (e.g. projector screen capture, microphones and video cameras). Most timetabled lecture sessions are automatically recorded, stored and managed within the University's virtual learning environment (VLE). Similar to Elliott and Neal (2016), on an individual student basis, the system records information of a range of viewing activity including when recordings are viewed and the length of that viewing.

3.2 Time frame, sample of students and sample modules

The time frame over which the student engagement with LC material is investigated here was defined so that for considered modules there was a consistent time-period between the start of students' teaching and their first assessment on each module. Moreover, data was collected from the start of teaching in the 2018-2019 academic year (start of 'Autumn' semester here taken as 2018-10-01), up to the end of the subsequent January assessment period (here taken as 2019-01-24). Due to assessments being sat at different times, the time period between the start of students' teaching and subsequent assessments will vary across the different modules considered.

The sample of students initially considered was compiled by identifying students who were registered in a programme with an accounting major. To create a sample of modules for analysis, all undergraduate modules taken by accounting students within the reference UK Business School were identified across, first (1), second (2) and final (F) years of study. These were then filtered subject to the following three conditions to ensure our sample was homogenous, allowing a greater understanding of students' engagement with LC material compared to only using a single module (Aldamen et al., 2015);

- i) LC material associated with a module was released progressively throughout the semester, e.g. LC recordings were released to students through the Autumn semester and up to January assessment period (across the 2018-2019 academic year).
- ii) The module had part of their assessment¹ for the 2018-2019 academic year in the respective January assessment period (2019), and importantly, had no earlier parts of assessment during the autumn semester.²
- iii) The considered assessment for the module was an assessment creating a single time point which students on a module would work towards, in terms of their use of LC material.

The modules identified based on the above criteria are summarised in Table 1 (noting the different modules have different numbers of lectures per week).³

Insert Table 1 about here

Table 1 illustrates the modules identified over the three academic years of study for the considered time period. The increased number of modules shown in Year F is a reflection on the increasing choice of modules available to final year students to allow specialisation. For each module, the number of accounting students active in the use of LC material are given as a fraction of the accounting students on the respective modules.

¹ Some modules contained within our analysis bridged two semesters. They were included within our sample with the condition that they had their first assessment during the January assessment period.

² Earlier assessments would bias the use of the released LC material, impacting activity through the autumn semester making comparison inappropriate.

³ No demographic data is included in this description of the data, since the priority of the study is to consider the genus of the 'when viewed' aspect of LC material engagement. No doubt future research may look at the variation in such viewing in terms of demographic details. Here variation in results are presented based on variations in perspective of formulisations of the 'when viewed' categorisations implemented.

Emphasis in the rest of the study is on those students who have engaged with the LC material. However, to position this, a module level analysis of the variation in the end of year module marks between those accounting students who used the LC material and those which did not is undertaken, see Figure 1.

Insert Figure 1 about here

In Figure 1, each scatterplot reports on a set of modules for a specific academic year. Each point shown shows the mean mark (out of a 100) for a module for students engaged with LC material (x-axis) and those not engaged with LC material (y-axis), see Table 1 for numbers of students of each group. The dashed line denotes where a pair of mean end of year module marks would be the same (for accounting students engaging and not engaging with LC material). For each module a simple two-tailed t-test (unpaired sample) is undertaken to check the difference between the respective two mean mark values. Across all years (first, second and final), there is a predominance of students with evidence of LC material engagement having higher marks than those with no evidence of LC material engagement on a module (notable exception is module 1A). There is, however, no statistical difference between pairs of mean marks (at 10% statistical level – see p values in scatterplots).

To elucidate the LC material engagement and to ensure that our sample of modules were consistent with our criteria (i), (ii) and (iii) given previously,⁴ the level of activity of students across the described modules (and years of study) are given in Figure 2, across the general time frame for this study (2018-10-02 to 2019-01-24). Following Elliot and Neal (2016), student engagement with LC material of less than one minute was removed from this study (this activity may be more associated with just checking they can access the material and not in terms of actual learning activity).

Insert Figure 2 about here⁵

In Figure 2, each graph shows the cumulative mean number of minutes viewed of LC material by each student in a module (only student engaging with LC), across the Autumn semester and up to the day of the associated assessment for that module (right hand end of lines stop at different times acknowledging this point). The use of the mean value here is to remove the impact of the variation in the number of students in the different modules. Inspection of the graphs, across the different years, identifies several interesting features:

⁴ Although the Business School engaged in a university wide policy where all lectures were recorded, there still remained two potential instances where LC recordings could be omitted: some lecture theatres were not equipped with relevant IT infrastructure to record lectures or individual staff members opted out of the University LC policy.

⁵ We note the start dates on these graphs are Tuesday 2nd Oct, this is because the LC material is updated overnight – hence any LC material produced on Monday 1st Oct would become available on Tuesday 2nd Oct.

- i) In general, across Year 1 modules, a noticeable increase in activity (cumulative mean minutes viewed) is noted starting just before and during the January assessment period (2019-01-02 to 2019-01-24).⁶ This increase in activity is less noticeable for Year 2 and Year F students. In the case of Year F students, the activity is much more 'near' constant across the whole considered time-period (2018-10-02 to 2019-01-24).
- ii) In the case of Year 2 and Year F, and in particular the modules 2C and FB, respectively, we see within the January assessment period a plateau followed by sudden activity. This may well be examples of students concentrating on other assessments prior to these specific ones, and then targeting the assessments of these two modules (2C and FB) after undertaking other assessments earlier in the assessment period.

The results surrounding Figure 2 have given an initial understanding on the use of LC material by students across different years of study and concomitant modules. Importantly, the evidence from Figure 2 confirms the need to look separately at different years of study of students. The next section develops this analysis by obtaining more granular detail and understanding of 'when viewed' use of LC material.

4. Derivation of 'when viewed' categorisations of LC material

Within this section, we outline the general 'when viewed' categorisations, to explore LC engagement by students. These categorisations are considered through several different perspective formulisations, which are also discussed.

4.1 Defining categorisations of 'when viewed'

The three categorisations, *Near-Event-Viewing* (NEV), *Get-Round-to-Viewing* (GRV) and *Revision-Time-Viewing* (RTV) are defined here (see Sarsfield and Conway, 2018, for an alternative two term categorisation), noting in their description whether they may be associated with student planned or reaction-based usage of LC material:

Near-Event-Viewing (NEV) – measures the 'near' lecture (event) time engagement of students with LC material associated with a module. It is the categorisation associated with the earliest viewing of LC material after being made available to students. Hence, for example,⁷ if a student was absent from a lecture, they could react by reviewing the LC material soon after the missed lecture, or noted uncertainty in a part of the lecture and view the LC material to fill the knowledge gap

⁶ For the module 1A, this is less sudden, it is noteworthy for this module (1A) its January assessment was the least weighted in contribution to the module's overall mark across considered Year 1 modules. This therefore may be evidence of LC material usage being affected by the associated weight of assessment contribution.

⁷ These are theoretical examples, and not premised on surveying of students on such experiences.

perceived. NEV may be viewed as reaction based, whereby such timing of usage is defined by when the LC material is first available to the students.

- *Get-Round-to-Viewing* (GRV) measures the activity of students developing their module learning resources after attending a lecture, so not an 'immediate' viewing activity. An example (acknowledging footnote 8) of this activity is where a student may be self-organising their learning material which will have grown in size and desire further clarification on certain points or concepts. In turn, this review activity could be a period prior to their more formal revision time activity. GRV may be viewed as planning based, whereby usage is defined by the student, being more an optional activity for students.
- *Revision-Time-Viewing* (RTV) measures the activity of revision time viewing of LC material. This period is labelled as a time when students will soon undertake their revision and need further clarification to form part of their impending assessment preparation. RTV may be viewed as reaction based, whereby such usage is defined by the impending associated assessment(s) on module(s) and their previous preparedness.

4.2 Perspective of 'when viewed' categorisations

Due to the conflicting evidence on use of LC material by students (see for example, O'Callaghan et al., 2017), we formulise our 'when viewed' categorisations from several different perspectives. At this time, it is important to ensure that we do not close down any untested theoretical perspectives which may arise in the future and so biasing future development of this work and use by others. Sarsfield and Conway (2015) offer support for such a multi perspective approach, stating (p. 2);

"This wide variation in reported use of LC may arise because, in general, each study reports the value for one specific context, and there are many differences in context and in the research methodologies adopted. Consequently, it is difficult to draw conclusions on the reasons for the variation or to compare results between the studies."

Hence the need to be open about such perspectives. Further, how the 'when viewed' question is perceived by universities may not be consistent, or even fully understood, so the desire here is to keep open the notion of 'when viewed'.⁸

Perspective 1: Equi-period when viewed formulisation

The first perspective formulisation of a 'when viewed' categorisation is based on an equal time-period approach. Specifically, the time between an individual recording being first viewed to the date of the

⁸ Aldamen et al. (2015) acknowledge the lack of information on whether the student actually viewed the material. However, as with Lewis and Sloan (2012), we assert that the student would have logged on with the intention to view the content of the recorded lectures.

associated assessment is split into three equal time intervals. Then, depending on when a student views a LC recording will dictate their association to the 'when viewed' categories of NEV, GRV and RTV, for that viewing occasion. To achieve this, we define $p_{i,j}$ (student s_i looking at recording r_j) as the proportion value of when viewed within the reference time period, and is given by;

$$p_{i,j} = \frac{\text{number of days from recording first viewed}}{\text{number of days between recording first viewed to assessment date'}}$$

where $p_{i,j}$ takes values in the range 0 to 1,⁹ for each of the LC recording viewing details included in the data set. It follows, for this equal time perspective, the 'when viewed' categorisation ($c_{i,j}$) of each student viewing is;

Categorisation =
$$c_{i,j} = \begin{cases} NEV & if \ 0 \le p_{i,j} \le 1/3 \\ GRV & if \ 1/3 < p_{i,j} \le 2/3 \\ RTV & if \ 2/3 < p_{i,j} \le 1 \end{cases}$$

Perspective 2: Equi-frequency when viewed formulisation

The second perspective formulisation of 'when viewed' categorisation is based on an equal frequency approach. For each LC recording there will be n_j viewings (from the first time viewed to the last time viewed up to the associated January assessment). Here, n_j is partitioned equally into three groups, forming the categorisations, NEV, GRV and RTV. For a recording r_j , all student s_i viewings are ordered, from the first to the last time viewed, termed $o_{i,j}$, i = 1, ..., n_j , with subsequent categorisation given by;

Categorisation =
$$c_{i,j}$$
 =
$$\begin{cases} NEV & \text{if } o_{i,j} \le n_j/3 \\ GRV & \text{if } n_j/3 < o_{i,j} \le 2n_j/3 \\ RTV & \text{if } 2n_j/3 < o_{i,j} \le n_j \end{cases}$$

The inference here is more from the perspective of student momentum (and not specific points in time), wherein the categorisations (NEV, GRV and RTV) are now defined for a single viewing relative to all viewings by the relevant student cohort.

Perspective 3: University-defined when viewed formulisation

Beyond the two formulaic (statistical) perspective formulisations of 'when viewed' categorisations previously defined, an attempt is made to also include a university-defined based perspective. This is an important consideration, since future use of such categorisations may be inclusive of factors specific to a module (or across a programme of modules etc.) known within the university. Here, without loss of generality, the university-defined categorisations are based on specific date ranges within the reference period of time considered (here 2018-10-02 to 2019-01-24), see Figure 3.

Insert Figure 3 about here

⁹ In the limit, if student s_i viewed recording r_j on the same day it was first viewed then $p_{i,j} = 0$, and if viewed on the day of the associated assessment then $p_{i,j} = 1$.

The diagram in Figure 3 illustrates a possible date range-based university-defined categorisation over the considered time period, from the start of the autumn semester to the end of the associated January assessment period. Inspection of the diagram shows three distinct date ranges, namely, the autumn semester (NEV - 2018-10-02 to 2018-12-13), the Christmas recess (GRV - 2018-12-14 to 2019-01-01) and the assessment period (RTV - 2019-01-02 to 2019-01-24). The allocation of 'when viewed' date ranges for each categorisation was derived through consultation with teaching teams across the considered modules, as an example of a university-based formulisation.

It is noted, for each of these perspective formulisations of categorisations, they are measured at the individual student viewing level, with each individual student viewing of a LC recording being categorised into one of the NEV, GRV and RTV 'when viewed' categories.

5. Student LC material usage based on 'when viewed'

With each student engaging with their own spread of LC recordings, irrespective of the categorisation perspective formulisations discussed in Section 4, the proportions of their viewing activity described in terms of NEV, GRV and RTV may also differ. A visualisation of these student proportions of viewing categorisations can be presented in a simplex plot (see Battisti et al., 2019), as illustrated in Figure 4 (note these diagrams do not show the amount viewed – only the 'when viewed' proportions of the different NEV, GRV and RTV categorisations for each student).

Insert Figure 4 about here

In Figure 4, for each year of study and perspective, a simplex plot (equilateral triangle) is presented. In a simplex plot, each accounting student is represented by a point, denoting the proportions of the categories, NEV (p_{NEV}), GRV (p_{GRV}) and RTV (p_{RTV}) [where $p_{NEV} + p_{GRV} + p_{RTV} = 1$], denoting their LC activity in NEV, GRV and RTV categorisations across all the LC material they have viewed. The nearer a point is to a vertex the more that student is associated with that categorisation of LC viewing engagement. The dashed lines inside the simplex plots denote the boundaries of the subregions of the simplex plot where a categorisation, NEV, GRV and RTV, is in the dominance for a student. At each vertex, values are given showing the number of students' majority associated with that categorisation.

Inspection of the simplex plots, across all years of study (rows) and perspective formulisations (columns), indicates a level of mixed viewing by a majority of the considered accounting students. For the equi-period and university-defined perspectives of categorisation, there is a noticeable limited number of students' majority associated to GRV categorisation. The rationale here being that students are predominantly either more NEV or RTV oriented, with a small number of exceptions (in these

perspectives), which could further suggest a reaction, rather than planned, based approach to the use of LC material is evident by students.

For ease of analysis, we re-present the simplex plots in Figure 5 to present a clearer visualisation of how students within our study have been categorised, based on majority association to a single NEV, GRV and RTV category.

Insert Figure 5 about here

From Figure 5, the equi-period categorisation perspective results suggest that Year 1 students are predominantly using LC material as part of their revision (Figure 5a) with very few using the material as a source for pre-assessment time development (low associations with NEV and GRV), confirming the trends identified in Figure 2. For Year 2 and Year F (Figures 5d and 5g), students appear to have shifted their LC material engagement, with an increasing number of students using the LC material for 'near-event' (NEV) and 'get-round-to' (GRV) purposes. For the equi-frequency perspective (Figures 5b, 5e and 5h), there exists a shifting of equal proportions of students associated with each categorisation, for the different years of study (1, 2 and F). This is somewhat understandable since this 'when viewed' categorisation (equi-frequency) is not time specific but more relative to the engagement across student cohorts (each student categorisation here is dependent on the levels of engagement of the other students). For the university-defined categorisation (Figures 5c, 5f and 5i), the results are similar to those for the equi-period categorisation. Indeed, there is a more pronounced movement to NEV as you consider Year 1 to Year F.

These findings, in particular, for equi-period and university-defined perspectives, are supported by Sarsfield and Conway (2018), which identified similar engagement with most use shortly after lectures and before assignments.

6. Further analysis

Similar to the calls of Banerjee (2021) and Fogarty (2020), Morris et al. (2019) states;

"... research demonstrates a contested space between staff and students in relation to the use and value of lecture recordings, a contested space that will need to be debated and resolved as universities grow their use of blended learning." (p.1)

We are motivated by these beliefs and undertake further analysis of LC material engagement, demonstrating the relevance of our proposed measures and our contribution to understanding the levels of engagement and impacts on performance of accounting students.

6.1 Measures of LC material usage and performance

To explore student engagement with LC material and the potential impact of such activity, we employ the following four measures in our further analysis:

- *Minutes Viewed* Each time LC material is accessed by a student, it is accessed for a period of time, measured here as Minutes Viewed. For each student, a mean amount of time viewed (only those viewings which were larger than 1 minute in duration) for LC material is determined, bringing together the number of times recordings are viewed and the duration of each viewing, creating a proxy for the average amount of LC material watched.
- *Percent Viewed* While the minutes viewed is an absolute value of student LC material engagement, the Percent Viewed is a measure of how much of a recording was actually viewed during each activity. The Percent Viewed measure uses the known length of the recording, and so a mean percentage value can be identified. It therefore offers a proxy for completeness of viewing of LC material.
- January Agg Mark This measure is a simple aggregated mark from the considered modules in this study (so for Year 1 (1A, 1B, 1C and 1D), Year 2 (2A, 2B, 2C and 2D) and Year F (FA, FB, FC, FD, FE and FF). This offers a proxy for the 'short-term' (immediate) impact of students' 'when viewed' engagement with LC material on performance within the assessment period the LC material engagement is considered up to.
- *Final Year Mark* For each student the final mark for the year is known, across all modules they will have taken. It is therefore a proxy for 'long-term' impact of students' earlier 'when viewed' engagement with LC material.

It is important to reflect that the engagement measures of Minutes Viewed and Percent Viewed offer relevant insights into the 'how' students are engaging with the LC material (while not a central focus of our study, are pertinent to gauge students' relationships with LC material).

6.2 Results

The following analysis considers the described measures in relation to our sample of accounting students, and their 'when viewed' LC material engagement categorisations. The consistency in the presented sets of results is to offer a future benchmarkable view of LC material usage (Minutes Viewed and Percent Viewed) and 'performance' (January Agg Mark and Final Year Mark). For each year of study (1, 2 and F), we present a set of boxplots that show the number of students in each categorisation, relevant F-statistics and concomitant p-significance for a One-Way ANOVA analysis.

Year 1

In Figure 6, each set of boxplots describe Year 1 accounting students and their association to each NEV, GRV and RTV categorisation, from different perspective formulisations, where we find the following:

Insert Figure 6 about here

- *Minutes Viewed* Across all categorisations (NEV, GRV and RTV) and formulisations (equi-period, equifrequency and university-defined), the majority of the mean minutes viewed by Year 1 students reside between 20 to 40 minutes. However, there is no statistical difference across the NEV, GRV and RTV categories (across all boxplots). In visual terms, the equi-period formulisation does suggest that within the RTV categorisation, Year 1 students viewed more during the revision time period, supporting our earlier analysis in Figure 2.
- *Percent Viewed* The results follow similarly those for Minutes-Viewed, here suggesting on average between 20 to 40 percent of a recording are viewed during any one LC viewing activity. In visual terms, the equi-period perspective again suggest Year 1 students viewed more (in percentage terms) of individual recordings during the revision time, however this remains statistically insignificant.
- January Agg Mark Across all categorisation perspectives, there are variations in the distribution of this 'short term' impact of LC material engagement on student performance (during the concomitant assessment period). This impact variation is also noted across the different NEV, GRV and RTV categories. For the equi-frequency formulisation there is 10% significance in the NEV category of students achieving a higher January aggregated assessment mark than students within the GRV and RTV categories. In visual terms the equi-period and university-defined formulisations suggest GRV grouped students also experience a better mark (but note the limited numbers of students in this category).
- *Final Year Mark* Across all categorisation perspectives, there is no statistical difference in the distributions of this 'long term' impact of LC material engagement on student performance (in terms of the students' overall marks for the year). This also infers no statistical difference across the NEV, GRV and RTV 'when viewed' categories. Visually, most noticeable is the higher final year marks of NEV students based on equi-frequency formulisation following the similar pattern with the January aggregated assessment marks (January Agg Mark).

Year 2

Similar to Figure 6, Figure 7 presents a set of boxplots for the Year 2 accounting students.

Insert Figure 7 about here

- *Minutes Viewed* Across all categorisation and formulisations, the majority of the mean minutes viewed reside between 15 to 35 minutes (but more towards the lower bound of this range) with a statistical difference across our categorisations, including the perspectives of equi-period and university-defined at the 1% significance level. For these perspectives they suggest the GRV categorised students have higher mean minutes viewed. Visually, the equi-period formulisation suggests RTV categorised students viewed more on average.
- *Percent Viewed* The results follow similarly those for Minutes-Viewed, here suggesting on average between 15 to 60 percent of a recording is viewed during any one LC viewing activity. There is again statistical significance in the equi-period and university-defined formulisations (at 1% significance). The inference being that GRV categorised students watch a greater percentage of a LC recording than other students (NEV and RTV), a noticeable statistically significant difference between planned (GRV) and reaction (NEV and RTV) engagement.
- January Agg Mark Across all categorisation formulisations, there are again variations in the distribution of January Agg marks for students in the different NEV, GRV and RTV categories. For the university-defined formulisation, students categorised as GRV on average outperform others at a 5% significance level. Visually, the equi-period and equi-frequency formulisations suggest that RTV categorised students underperform compared with others in their cohort.
- *Final Year Mark* The results have similarities with those for our concomitant January Agg Mark. For the university-defined formulisation, GRV again outperform the other categories at the 10% significance level. Visually, the equi-period and equi-frequency formulisations support the findings of the university-defined perspective, specifically illustrating the underperformance of RTV categorised students.

Year F

Finally, Figure 8 illustrates our results for the final year (Year F) accounting students.

Insert Figure 8 about here

- *Minutes Viewed* Across all categorisation and formulisations, the majority of the mean minutes viewed reside between 10 to 30 minutes (but more towards the lower bound of this range). There is statistical difference across the NEV, GRV and RTV categorisation in regard to the equi-frequency formulisations (at 5% significance), with NEV categorised students viewing the most on average. In visual terms, across all categorisation formulisations, NEV categorised students view the most LC material during their final year.
- *Percent Viewed* As with previous cohort years, the results follow similarly those for Minutes-Viewed, here suggesting a range of between 10 to 40 percent of a recording is viewed during any one LC

viewing activity. There is again statistical significance in the equi-frequency formulisation result at the 5% significance level. The inference being a decreasing percent of recordings viewed, through the NEV, RTV and GRV categories, respectively. In visual terms, for the equi-period and university-defined formulisation results, the NEV categorised students watch greater percentages of recordings.

- January Agg Mark Across all categorisations, there are similarities in the distribution of the January assessment marks for students in different NEV, GRV and RTV categories. For the equi-frequency formulisation there is a 1% significance where decreasing average marks were seen in the NEV, GRV and RTV categories, respectively. In contrast, for the equi-period formulisation, NEV categorised students perform better in their January assessment than the others at the 5% significance level. In visual terms, students categorised as NEV outperform the remaining students in all of our alternative perspectives.
- *Final Year Mark* Across all categorisations, there are similarities in the distribution of final year marks for students in different NEV, GRV and RTV categories. Indeed, with a near consistent 1% statistical significance, NEV, GRV and RTV associated students have decreasing levels of final year marks.

7. Discussion

The results presented in the previous section allow an analysis of student engagement with LC material and subsequent impact (in levels of engagement and performance). The first pronounced observation is the change in how students use LC material as they transition through their degree programme (through each year of study). As we previously noted, within Figure 2, first year students predominantly focussed their engagement with LC just prior to the respective assessment, while students in their final year of study, engaged more consistently over the teaching period and subsequent assessment period. For the study's sample of accounting students, the average number of *minutes viewed* across the three years of study suggest a slow decrease in the mean minutes viewed as students' progress through their studies. This supports the LC material engagement described in Figure 2, where students are now spreading their use of LC material over a longer time period compared to a focussed intense period prior to their assessment. This is supported by the different student associations to the NEV, GRV and RTV categories, where there appears a gradual movement away from RTV, through GRV to NEV (noting in our study different students are considered across the different years of study).

The previous paragraph suggested variations in how students engage with LC depending on the year of study of the students. The literature has demonstrated that students' conception of learning can be developed throughout their educational journey (Abhayawansa et al., 2017), while different clusters of students may have different goals (Ebbert and Duke, 2020) potentially impacting how LC is used. LC as a learning material appears to be primarily used for reactive learning prior to assessments in year 1 of study but was used more purposeful and planned for those in their final year of study. This is corroborated with the results for percent viewed as we see that there exists a slight increase in the percent of a recording viewed for students from Year 1 to Year 2 of study, but then a noticeable decrease in the percent of a recording viewed for students in their final year (across all categorisations). This potentially suggests that students are less reliant on LC material within their final year.

In relation to student performance, students' engagement with LC material is most statistically significant for final year students. For both our performance measures of *January Agg Mark* and *Final Year Mark*, we see a noticeable decrease in performance against NEV, GRV and RTV, respectively for final year students. The previous measures of viewing duration support this result, in that for students further into their studies, the use of LC material is different (for students in their final year there is earlier engagement with LC material and a subsequent impact on performance).

Overall, our findings across such years of study suggest that student engagement behaviour with LC material is different across the different years of study, giving educators insight into the varying relevance and effectiveness of LC. With such information, we can raise pertinent questions such as: why is student behaviour different depending on year of study? Are differences in engagement behaviour linked to individual student learning development or self-regulation? Is it in response to their understanding or experience of LC material which they self-navigate? As educators, do we need to facilitate student understanding of how to effectively use LC material as potentially it can impact overall performance? These are questions which our study can now support other educators in addressing (including to consider students in longitudinal studies).

8. Conclusions

Due to conflicting evidence offered by the contemporary literature, this study undertakes an exploratory study of a key underlying dimension of lecture capture (LC) – students' actual engagement. We address this by asking the research question 'When do students view LC and does it impact their learning?'.

The main emphasis in this study has been the notion of 'when viewed' of LC material by students. We demonstrate that a nuanced analysis can yield significant results, for example by considering different years of study in the same academic year, we have identified different LC material engagement behaviours exhibited by accounting students. Specifically, Year 1 students in our sample primarily view LC material just before and during the assessment period compared to final

year students who take a more consistent viewing approach. The 'when viewed' categorisations introduced within this study, *Near-Event-Viewing* (NEV), *Get-Round-to-Viewing* (GRV) and *Revision-Time-Viewing* (RTV), can allow educators to explore how students interact with LC material to inform and appraise their learning design. The very consideration of such categories is an admittance of the differences taking place in the use of LC by students and importantly across different years of study.

As many authors in the extant literature have declared (Veletsianos, 2016; Morris et al., 2019; Banerjee, 2021), the need for a wider exploration of such LC based student engagement is warranted due to the complexity of digital innovation and its application to the higher education sector, for which the current COVID-19 pandemic has exacerbated and pushed to the forefront of many universities (Sangster et al., 2020). The different perspectives of 'when viewed' categorisations presented, equiperiod, equi-frequency and university-defined, exemplify this. We caution the 'close-down' of early investigations into this area due to the complex nature of student learning behaviour within the changing landscape of HE delivery. We further highlight that a wider appreciation and application of data analytics to this area can benefit the development of student support and in turn, the student experience.

Four engagement and performance measures are considered, *Minutes Viewed*, *Percent Viewed*, *January Agg Mark* and *Final Year Mark*. Importantly, these measures attempt to reflect 'how' students engage with (Minutes Viewed and Percent Viewed) and the impact of (January Agg Mark and Final Year Mark) the student relationship with LC material. The different categorisations of students (across different perspectives) are compared against these measures. The statistically significant results identified demonstrate the relevance of understanding different student LC engagement behaviour, especially within different subject contexts. Through the categorisations, NEV, GRV and RTV, a novel inference has been made, how students use reactive (NEV and RTV) and planned (GRV) based engagement behaviour towards LC material. It would be interesting to take further the efficacy of when students engage with LC in a planned or reactive way, potentially as a behavioural framework.

By addressing 'When do students view LC and does it impact their learning?', we have been able to explicate an under researched area of accounting student behaviour and use of IT innovations, specifically here, LC. The measures and outcomes we present allow a greater understanding of how students interact with IT advances which are becoming more prevalent, both in response to the recent pandemic and due to a greater focus on student-centric learning. Both academics and practitioners within higher education and the wider accounting community can explore their own student cohorts and educational/training settings using the measures we present here, gaining important insights into the efficacy of their own online learning resources and environment. Our study will add to the

continual and contested discussion of LC as demanded by several authors, including Banerjee (2021), Fogarty (2020) and Morris et al. (2019).

This study exposes a number of other interesting directions for future research. Firstly, as with other research, a longitudinal study of the same student cohort will allow teaching and learning teams to develop a deeper understanding of their students while being able to take into account, other issues such as changes in the University learning environment or other external factors beyond their control. Early results in this study (see Figure 2) showed the variation in engagement with LC material depending on whether the students were in their first, second or final years of study. Further investigations including longitudinal oriented (e.g. following same students over progressive years). and qualitative studies should be explored in future research to gain further insights.

Secondly, timely analysis of this data would allow teaching and learning teams to be more reactive during urgent internal or external shocks such as the current global pandemic. For example, if students LC material engagement are noted to be primarily residing within the NEV category, staff can seek further understanding from students whether there exist any barriers for engagement or introduce further support or interventions to facilitate students to transition to a more appropriate use. This action could subsequently impact student wellbeing and achievement. In contrast, where a student may be majority associated with RTV, then, as the results suggest, early awareness by staff may allow a form of conversation to take place with the student, to ask about NEV and GRV based engagement, which may benefit them in long term performance terms.

This study has taken the proactive step of not considering engagement other than the viewing of LC material as for many UK higher education institutions, data on all student engagement points may not be available (Sarsfield and Conway, 2018). A key feature of this choice is that these results are future repeatable by any institution, without loss of generality to the utilisation of other engagement data which may or may not be consistent across different universities. Having said this, aspects of the above future thoughts can be considered using LC material only. However, knowledge on other dimensions of engagement by the students could help to build a more complete picture of their engagement, as well as gauging the impact of any remedy/action on other aspects of the student experience which is ever important as it is likely the HE sector will emerge as a blended learning sector.

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Year	Module label (Student numbers)
1	1A (57/105), 1B (77/108), 1C (98/108), 1D (65/107)
2	2A (103/143), 2B (84/121), 2C (92/120), 2D (51/74)
F	FA (66/101), FB (79/116), FC (70/98), FD (85/116),
	FE (65/74), FF (78/116)

Table 1. Breakdown of modules and associated numbers of students considered in this study.

Year: reference to the year of study of a typical three-year undergraduate degree where F = final year. Student numbers: the number of students active in the use of LC material as a fraction of the total number of students on that module

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Figure 1. Scatterplot of mean end of year marks (out of 100) on modules of students who have and have not used LC material

Figure 2. Accounting student LC material activity across first (a), second (b) and final (c) academic years of study, measured as cumulative to-date based mean number of minutes viewed by a student, across the general time frame for this study (2018-10-02 to 2019-01-24)



Figure 3. Diagram of considered timeframe of academic year considered (with graphical universitydefined categorisations).





Figure 4. NEV, GRV and RTV categorisation of accounting students across academic years of study and perspective^{*}

* Differences in totals of students across same year simplex plots is due to different numbers of Accounting students not having single majority association to a single categorisation.



Figure 5. NEV, GRV and RTV majority association of accounting students across academic years of study (rows) and perspectives (columns)

Figure 6. NEV, GRV and RTV majority association of Year 1 Accounting students, across perspectives, equi-period (a, b, c, d), equi-frequency (e, f, g, h) and university-defined (I, j, k, I), against the measures, Minutes viewed (a, e, i), Percent viewed (b, f, j), January agg mark (c, g, k) and Final year mark (d, h, i)*



* The Minutes Viewed measure is based on a range 0 up to the maximum sized recording available across all modules and academic years – here found to be 103 minutes (associated with a double lecture), hence the 100 value on the axis is not to be confused with the other 100 values for the other measures (which are natural upper bounds – whether percentage or marks).

Figure 7. NEV, GRV and RTV majority association of Year 2 Accounting students, across perspectives, equi-period (a, b, c, d), equi-frequency (e, f, g, h) and university-defined (I, j, k, I), against the measures Minutes viewed (a, e, i), Percent viewed (b, f, j), January agg mark (c, g, k) and Final year mark (d, h, i)*



* The Minutes Viewed measure is based on a range 0 up to the maximum sized recording available across all modules and academic years – here found to be 103 minutes (associated with a double lecture), hence the 100 value on the axis is not to be confused with the other 100 values for the other measures (which are natural upper bounds – whether percentage or marks).

Figure 8. NEV, GRV and RTV majority association of Year F Accounting students, across perspectives, equi-period (a, b, c, d), equi-frequency (e, f, g, h) and university-defined (I, j, k, I), against the measures, Minutes viewed (a, e, i), Percent viewed (b, f, j), January agg mark (c, g, k) and Final year mark (d, h, i)*



* The Minutes Viewed measure is based on a range 0 up to the maximum sized recording available across all modules and academic years – here found to be 103 minutes (associated with a double lecture), hence the 100 value on the axis is not to be confused with the other 100 values for the other measures (which are natural upper bounds – whether percentage or marks).