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To capture the research landscape of lecture capture in university education

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To capture the research landscape of lecture capture in university education

Abstract: The use of lecture capture has been burgeoning in the higher education sector. Scholarly interest on the topic is also on an upward trajectory. Hence, the goal of this paper is to clarify the literature on the use of lecture capture in higher education through a systematic review, which involved 71 articles that came from Scopus and Education Resources Information Center (ERIC). The systematic review revealed that most research focused on university education in the US, the UK and Australia. The most studied Science, Technology, Engineering and Mathematics (STEM) subject area in the sample is Biological Sciences. In contrast, the most studied non-STEM subject area is Business/Economics/Management. In terms of methods, descriptive and exploratory research dominates the research landscape while causative evidence is relatively limited. The literature includes two overarching research streams: While one focuses on the benefits of lecture capture, the other focuses on its drawbacks. Apparently, the assumption among most students is that lecture capture is helpful for learning, and among staff is that it takes a toll on attendance. Future research needs to reconcile students' perception of lecture capture, instructors' perception of lecture capture, and the reality of lecture capture. On the practical front, students should be explicitly told about the benefits and the drawbacks of lecture capture. This would ensure that they make the most of the technology. Educators are urged to reflect on why students should be attending the face-to-face sessions, and thereafter also watch the recorded lectures.

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1. Introduction

Digital technology has been making rapid inroads in curriculum design. Specifically, lecture capture is increasingly becoming popular all across the globe (Stokel-Walker, 2019). Consistent with its surging popularity among practitioners, scholarly interest on the topic has also been on the rise in recent years. The diversity in the literature calls for synthesising the research landscape of lecture capture (Nordmann et al., 2019).

As a response to the call, the goal of this paper is to clarify and consolidate the accumulated state of knowledge regarding the use of lecture capture in higher education. The focus is particularly on higher education due to two reasons. First, the use of lecture capture is burgeoning in this sector. Over 1,000 higher education institutions worldwide use it to record more than 100 hours of lecture video every month (Stokel-Walker, 2019). In countries such as the US and the UK, more than 4 in 5 institutions utilise lecture capture (Newland, 2017; Panopto, 2020). The technology has grown in stature to such an extent that it is now noted by its absence rather than presence in higher education (Cramer, 2015; Ibrahim et al., in press).

Second, university students are more independent than their junior counterpart such as students in K-12 (Ary et al., 2002; Belland and Drake, 2013), who are likely to experience greater parental mediation—strategies that parents use to monitor and regulate children's use of digital media (Warren, 2001). Therefore, lecture capture use by the former is likely to be more self-regulated and self-paced. As a result, the literature on the use of lecture capture in the higher education setting is likely to be more nuanced than that in the K-12 realm.

To achieve the research goal, a systematic literature review was conducted with the following objectives: (1) To identify the contexts that lecture capture research has explored in higher education, (2) To recognise the methods that lecture capture research in higher education has employed, and (3) To analyse the overarching research streams in the current body of the lecture capture literature in higher education.

The paper is significant on three fronts. First, the systematic review enables educators to better understand how university students use lecture capture. Second, it contributes to the academic discourse on the use of lecture capture in higher education by identifying several under-investigated research contexts, research methods, and research themes. Third, it dovetails extant systematic reviews on the broader theme of technology-enhanced learning. For one, Kay (2012) reviewed the literature on the use of vodcasts—also called video podcasts—in education including secondary school and elementary school. In contrast, this paper casts the spotlight specifically on the use of lecture capture in university education. More recently, O'Callaghan et al. (2017) conducted a systematic review on the use of web-based lecture technologies such as lecture capture, podcasts, and video streaming in Australia. In contrast, this paper seeks to offer a more in-depth review of lecture capture only but without limiting the geographical scope. In an even more recent work, Clunie et al. (2018) reviewed the literature on technology-enhanced learning tools in anatomy education—a field that is known to be at the forefront of integrating innovative technologies in the curriculum. In contrast, this paper does not restrict the review to any discipline or sub-discipline.

The paper proceeds as follows: Section 2 offers a conceptualisation of lecture capture. Section 3 describes the methods employed to conduct the systematic review. Section 4 discusses the findings. Finally, Section 5 highlights the paper's contributions, limitations, implications for practice, and opportunities for further research.

2. Conceptualising Lecture Capture

Lecture capture, as the name suggests, essentially consists of recorded or captured lectures that are then used as a learning resource by students. The recording can take place either in vitro—where lectures are delivered without any audience just for the purpose of being captured—or in vivo—where live face-to-face lectures in front of students are captured in real time (Pale et al., 2014). The scope of this paper is trained on the latter.

Meanwhile, a live face-to-face lecture in front of students can take place in three formats. In one, the instructor interacts with students by writing on a traditional blackboard. No digital audio-visual element is involved. In the second format, the instructor uses the lecture-room projector to present a slideshow to the students. Other audio-visual learning materials

including smart boards and videos can also be displayed. The third format is one that includes a combination of the first two.

For the purpose of this paper, lecture capture encompasses recording the activities on the lecture-room projector during a live face-to-face lecture, which takes place based on either the second or the third format, for subsequent dissemination among the students enrolled in the course. The recording notwithstanding, the students are expected to attend the face-to-face sessions. Some versions of such a lecture capture system record the lecture-room projector along with the instructor's voice. Other more encompassing versions record the instructor along with the students—both speech and video (McCunn and Newton, 2015; Newton et al., 2014). The recordings are often timestamped for ease of navigation, and can be accompanied with captions (Gorissen et al., 2015).

Given the increasing smartphone penetration in people's everyday lives, lecture capture provides students, even those with a range of disabilities, with on-demand any time-any place access to lectures (Ibrahim et al., in press; McCunn and Newton, 2015). The online recordings serve as long-lasting digital footprints of live lectures that are otherwise ephemeral. Watching lecture capture is a key step in contemporary education. It allows students to revisit lectures that they had either missed or failed to understand, thereby promoting inclusivity—a theme that has been attracting much attention among higher education leaders and policy makers. Inclusive higher education seeks to not only engage every student without exclusion but also modernise the learning environment to meet contemporary learning needs (Blessinger et al., 2018; Thomas and May, 2010). It also fits well with the 2030 agenda for sustainable development of leaving no-one behind (United Nations, 2015). Clearly, the use of lecture capture seems to be a step in the right direction in this digital economy insofar as achieving inclusivity and equal access to higher education.

Using lecture capture is however a social process that sees the confluence of not only technology but also the behaviour of students and educators (Kirschner et al., 2004). Hence, it is important to cast the spotlight on lecture capture through the lens of learning theories. The two key paradigms that lie at opposite ends of the spectrum are behaviourism and constructivism (Bichelmeyer and Hsu, 1999; Radianti et al., 2020). Behaviourism assumes objectivity and the existence of a single reality. Students acquire knowledge passively from instructors who aim to transfer the correct behavioural response to external stimuli. Learning motivation is extrinsic, involving positive and negative reinforcement. There is an emphasis on repetition and rote learning (Ertmer and Newby, 1993).

In contrast, according to constructivism, there are multiple realities that are subjectively constructed. Students, who are self-regulated, actively construct their own understanding of reality by linking new information to their prior experiences (Ertmer and Newby, 1993). Instructors serve as learning facilitators, rather than knowledge transmitters, who emphasise on problem solving (Bichelmeyer and Hsu, 1999). Since knowledge acquisition depends on how information is received and assimilated, digital technology can be particularly helpful for constructivist learning design (Radianti et al., 2020). Watching lecture capture after attending the face-to-face lectures is likely to help students in knowledge building from half-baked notions, thereby enabling them to gradually develop a grasp over complex problem solving (Scardamalia and Bereiter, 2010).

Given this conceptualisation of lecture capture that fits with constructivism, the following section presents the methods of the systematic review. The findings can be beneficial for designing technology-enhanced constructivist learning through the use of lecture capture.

3. Methods

3.1. Literature Search

To collect relevant papers in English language as exhaustively as possible, a literature search protocol was necessary. For this purpose, pilot searches were conducted on Scopus, the largest database of peer-reviewed literature (Maflahi and Thelwall, 2016). Three observations arose. First, relevant papers used at least one of the following six alternative phrases: "lecture capture," "lecture recording," "lecture streaming," "recorded lectures," "screencasting," or "screencast." Second, relevant papers in the context of higher education used at least one of the following three alternative phrases: "university education," "higher education," or "university teaching." Third, when the search was applied on full texts, several irrelevant articles were retrieved and the noise exceeded the data. The volume of noise was possible to reduce considerably by restricting the search on titles, abstracts and keywords.

Guided by these initial observations, the following search query was used: ("lecture capture" OR "lecture recording" OR "lecture streaming" OR "recorded lectures" OR "screencasting" OR "screencast") AND ("university education" OR "higher education" OR "university teaching"). The use of such Boolean operators is common in systematic literature reviews (Pal and Chua, 2016; Zhang et al., 2015). The search query was applied to titles, abstracts and keywords.

Two databases were used for searching: Scopus and Education Resources Information Center (ERIC). Scopus was chosen because it is well known for its comprehensive coverage (Maflahi and Thelwall, 2016). It indexes articles retrievable through several other independent academic databases such as Emerald and Springer. ERIC was chosen because it is a repository dedicated to the education literature (Clunie et al., 2018). General Google searches were avoided to exclude grey literature that may not have undergone scientific peer-review (Yli-Huumo et al., 2016). The peer-reviewed literature retrievable through Google are anyway expected to be obtained via Scopus and/or ERIC.

The search was restricted to journal articles as the inclusion criterion. This was necessary for quality control as journal articles undergo more rigorous peer-review compared with either conference proceedings or book chapters. No date restriction was applied because the use of lecture capture is not an age-old phenomenon, and is therefore self-limited to the last two decades. By conducting the search in April 2020, 185 articles were retrieved.

3.2. Literature Screening

Figure 1 depicts the literature screening process that involved three steps. In the first step, the initial corpus of 185 articles (65 from Scopus + 120 from ERIC) was checked for duplicates. A total of 46 duplicates were identified, and eventually removed.

In the second step, the relevance of the remaining 139 unique articles was checked by reading their titles and abstracts. Forty articles that were thematically irrelevant were removed. Whenever the relevance of an article was not possible to determine with certainty, it was retained. Seven articles related to lecture capture were also excluded. These either described the authors' personal experiences (Newton et al., 2014), did not report any empirical work (Zandona et al., 2016), or focused on the technological implementation of lecture capture (Valor Miró et al., 2014)—which are beyond the scope of this systematic review. Taken together, 47 articles were excluded.

In the third step, the relevance of the remaining 92 articles was checked through analyses of their full-texts. Twenty-one articles were further excluded because they did not conform to the paper's conceptualisation of lecture capture—recording of live lectures for students who are also expected to attend the sessions face-to-face (cf. Section 2). For example, Loch et al. (2014) focused on video recordings that were not recorded during live lectures. Bahnson and Olejnikova (2017) looked into recorded lectures but did not require students to attend the live sessions face-to-face. All such instances had to be removed. Finally, 71 articles were admitted for the systematic literature review. Figure 2 shows their year-wise distribution.

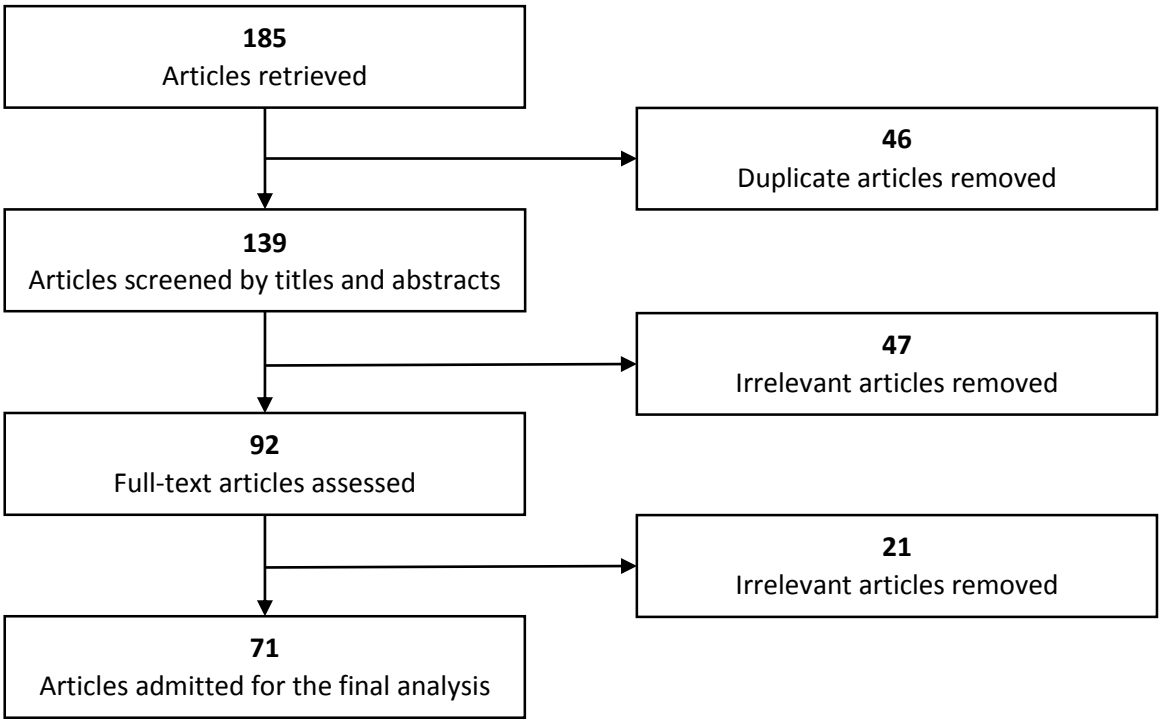

Figure 1: The literature screening process.

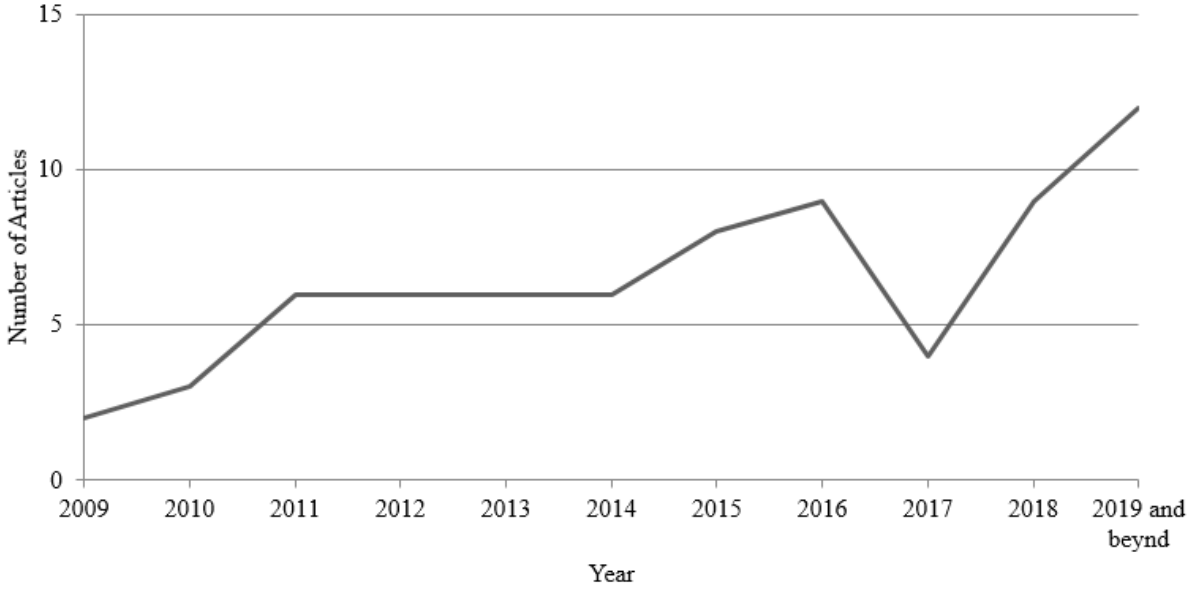

Figure 2: Year-wise distribution of the relevant articles on lecture capture in higher education.

3.3. Literature Coding and Analysis

The coding and analysis involved two steps. In the first step, the 71 articles admitted for the systematic literature review were carefully inspected. The researcher used a Microsoft Excel spreadsheet to record the following data points: study details (e.g., year of publication, geographical location of the study), research methods (e.g., qualitative / quantitative / mixed, correlational / causative), sample characteristics (e.g., subject area, undergraduate / postgraduate), lecture capture characteristics (e.g., length of recordings, number of recordings), and finally thematic focus of the paper—as identified through iterative rounds of coding (e.g., students' attendance, academic performance) coupled with the finding with respect to the theme.

In the second step, another coder, who was a full-time postgraduate student in a large university in the UK, independently inspected all the articles. The goal was to cross-check the entries in the spreadsheet obtained from the previous step. All inconsistencies were resolved through discussion. Thus, the final spreadsheet reflected full inter-coder agreement between the researcher and the independent coder.

The involvement of the researcher, who dons the hat of an instructor with experience of leading courses that are lecture captured, along with a student in the coding procedure was particularly necessary to minimise any bias. After all, lecture capture divides instructors and students—as reflected later in the findings too.

4. Findings and Discussion

4.1. Contexts Studied by Lecture Capture Research in Higher Education

As depicted in Figure 3, among the 71 articles, much of the scholarly attention has been trained on the US (18 articles, 25.35%), the UK (18 articles, 25.35%), and Australia (15 articles, 21.13%). Beyond these top three countries that account for more than 70% of the sample, other sparingly studied research contexts include Canada, the Netherlands, Malaysia, Qatar, Taiwan, Austria, Germany, Turkey and the UAE.

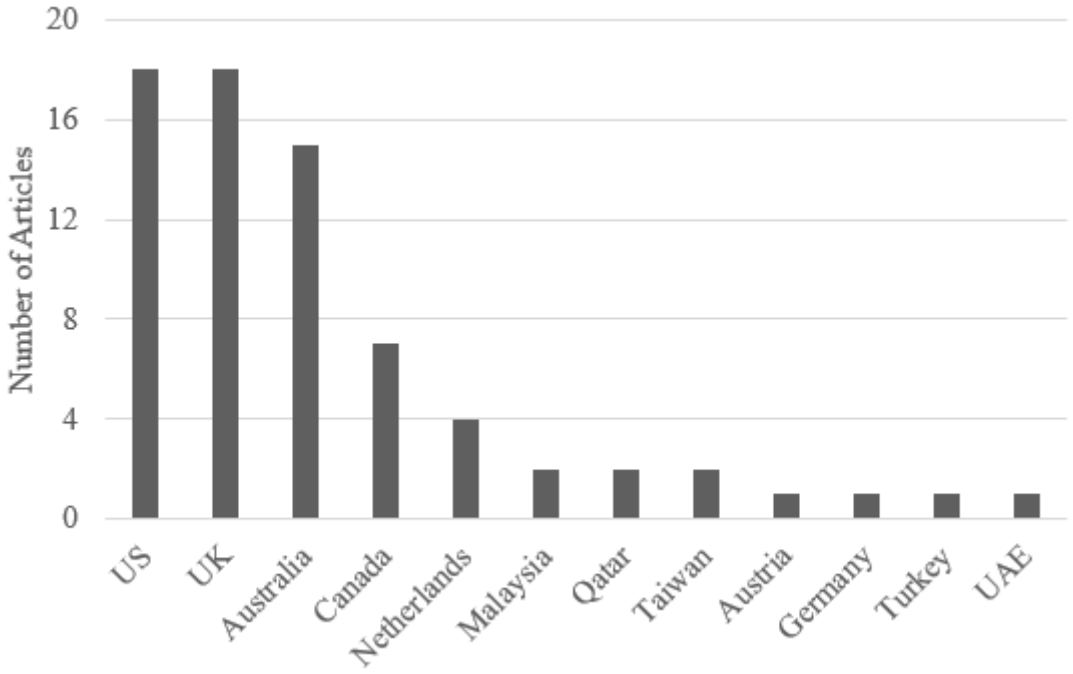

Figure 3: Country-wise distribution of lecture capture research.

In the meantime, recent statistics suggest that more than 1,000 higher education institutions worldwide use lecture-recording tools such as Panopto to record more than 100 hours of lecture video every month (Stokel-Walker, 2019). Thus, the geographical distribution of the articles does not seem to be in line with the current trends of lecture capture usage.

Furthermore, 64 of the 71 articles (90.14%) confined the context of investigation to data from just one institution. Among the seven exceptions, six drew data from multiple institutes (Farooq et al., 2017; Gorissen et al., 2012, 2013; Gosper et al., 2010; Nightingale et al., 2019; Trenholm et al., 2019), whereas the other drew data from different campuses of the same institute (Dommett et al., 2019).

Only one article reported a comparative analysis between two countries, namely, Australia and the UK (Trenholm et al., 2019). Some discrepancies were identified. For example, in Australia, regular and irregular lecture capture users differed in terms of age. However, such a difference was non-significant in the UK. Given the limited research, this paper calls for more cross-country and cross-cultural investigations that can offer insights into differences in students' motives, behaviours and attitudes regarding lecture capture.

As shown in Figure 4, the most studied Science, Technology, Engineering and Mathematics (STEM) subject area in the sample is Biological Sciences (29 articles, 40.84%). Informed by Nightingale et al. (2019), Biological Sciences in this paper include biochemistry, health

science, nursing, midwifery, medicine, pharmacy, and psychology. In contrast, the most studied non-STEM subject area is Business/Economics/Management (16 articles, 22.54%).

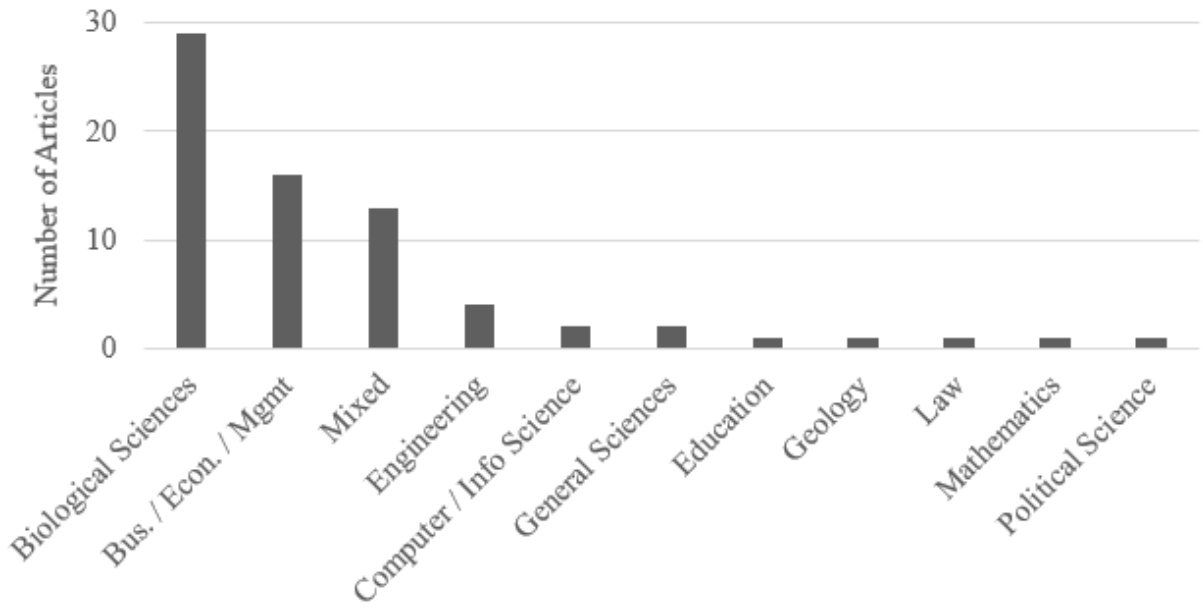

Figure 4: Subject area-wise distribution of lecture capture research.

Most (58 articles, 81.69%) of the 71 articles studied lecture capture from a student-only perspective while only three had a staff-only perspective (Freed et al., 2014; Germany, 2012; Joseph-Richard et al., 2018). The remaining 10 articles offered a greater degree of triangulation by shedding light on the two perspectives in tandem. Thus, students were involved as research participants in 68 articles (58 + 10). Furthermore, staff members were involved as research participants in 13 articles (3 + 10).

Among the 68 articles involving students, the spotlight was predominantly on those pursuing only undergraduate degrees (53 articles) even though they were not always clearly differentiated in terms of their year of study. Only one article specifically focused on executive students (Farooq et al., 2017). Another two focused exclusively on postgraduate students (Baker et al., 2018; Saunders and Hunt, 2015). Yet another four studied a mixture of undergraduate and postgraduate students (Dommett et al., 2019; Dona et al., 2017; Gosper et al., 2010; Taplin et al., 2011). The scope of Caglayan and Ustunluoglu (in press) was trained on not only undergraduate and postgraduate students but also what are referred as associate students. In addition, there are a few instances where the degree pursued by the students was not clarified explicitly (e.g., Groen et al., 2016). Nevertheless, it is clear that lecture capture research is limited in the contexts of postgraduate and executive education. Future research needs to plug this contextual gap in the literature. Undergraduate students are expected to have a relatively lower level of maturity than either postgraduate or executive students. Therefore, findings gleaned from the former cannot be generalised to the latter.

It is conceivable that the use of lecture capture throughout the world may differ in terms of factors such as length of recordings, number of recordings, and availability of recordings. Findings cannot be assumed to be the same regardless of these contextual factors. Yet, several articles refrained from providing such details (e.g., Cooke et al., 2012; Germany,

2012; McCunn and Newton, 2015). Among the handful of articles that included such a level of details, length of the lectures captured was mostly reported as one hour or less (e.g., Brooks et al., 2014; Elliot and Neal, 2016; Williams et al., 2016). In three articles, duration of the lectures varied from one to two hours (Chapin, 2018; Jones and Olczak, 2016; Trenholm et al., 2019). In yet another three articles, lectures were as long as three hours (Bollmeier et al., 2010; Chen and Lin, 2012; Owston et al., 2011). The number of lecture recordings varied drastically from as low as two (Hadgu et al., 2016) to as high as 47 (Guy et al., 2018). Few articles stated exactly when the lecture recordings were released, and how long they remained available to students. A notable exception is Bollmeier et al. (2010), according to which students had access to lecture recordings for 72 hours following the live lectures.

4.2. Methods Employed by Lecture Capture Research in Higher Education

Lecture capture research does not seem to suffer from mono-method bias. This is evident from the widespread use of mixed methods. Of the 71 articles, 27 (38.03%) employed quantitative and qualitative methods in conjunction. Among the rest, purely quantitative works (40 articles, 56.34%) outnumber those that are purely qualitative (4 articles, 5.63%).

Even in terms of data source, several articles complemented the use of surveys and interviews with focus group discussions as well as tracking of student-specific data. In particular, 45 articles (63.38%) reportedly administered surveys. Student-specific data—ranging from attendance and academic performance in assessments to lecture capture usage via online logs—were tracked in 40 articles (56.34%). The use of focus group discussions was evident in 13 articles (18.31%). Experiments were employed in 11 articles (15.49%). Seven articles (9.86%) conducted interviews.

As the widespread use of lecture capture continues to spawn a growing corpus of digital data, the scholarly community is also starting to employ novel analytical techniques on student-specific data. Three such examples are illustrated as follows: Brooks et al. (2014) used unsupervised machine learning algorithms on students' data. Luttenberger et al. (2018) applied latent class analysis. More recently, O'Brien and Verma (2019) applied cluster analysis. All of these essentially leveraged data analytics to make sense of students' lecture capture utilisation patterns.

Nevertheless, correlational, descriptive and exploratory research seems to dominate the research landscape of lecture capture while causative evidence, which is possible to glean only through experiments, is still relatively limited. This could be attributed to the logistical difficulty in arranging randomized samples, random assignments, and controlling extraneous variables in university education. Drouin (2014) and Traphagan et al. (2010) are among the few exceptions that used quasi-experimental research designs to infer causation.

Moreover, the methods of most articles were driven by practical concerns, and not by theory. Only a handful of works were explicitly rooted in theory. For example, Farooq et al. (2017) and Nair et al. (2015) were rooted in the unified theory of acceptance and use of technology. However, none of the articles were situated within any pedagogical or technology-mediated learning frameworks.

In Biological Sciences—the most studied STEM subject area (29 articles), the distribution of research methods is as follows: 9 mixed methods + 19 quantitative + 1 qualitative. At a granular level, this body of research contains 18 surveys, 17 studies that involved tracking student-specific data, five focus group discussions, five experiments, and one interview.

In Business/Economics/Management—the most studied non-STEM subject area (16 articles), the distribution of research methods is as follows: 5 mixed methods + 11 quantitative. At a granular level, this literature encompasses 10 surveys, 11 studies that involved tracking student-specific data, one focus group discussion, and two experiments. Appendix A summarises the findings of the paper corresponding to research context (Objective 1) as well as research methods (Objective 2).

4.3. Overarching Research Streams in the Lecture Capture Literature in Higher Education

Reading of the lecture capture literature highlighted two overarching research streams that almost seem to collide head-on. While one research stream focuses on the benefits of lecture capture, the other focuses on its drawbacks. This is perhaps unsurprising as lecture capture tends to polarise views. Some consider it a priceless adjunct to promote inclusive education (Blessinger et al., 2018; Mallinson and Baumann, 2015) whereas others view it as a perfect recipe for non-attendance (Aldamen et al., 2015).

Still, the benefits of lecture capture (Table 1 and Appendix B) that this systematic review identifies outnumber the drawbacks (Table 2 and Appendix C). The top five benefits of lecture capture are as follows: It facilitates students' learning and/or revision (41 articles, 57.75%), positively impacts students' academic performance (39 articles, 54.93%), allows students a better work-life balance (31 articles, 43.66%), helps students fill in lecture notes (21 articles, 29.58%), and aids students in revisiting difficult concepts (19 articles, 26.76%).

In contrast, the top five drawbacks of lecture capture are as follows: It has an adverse impact on lecture attendance (20 articles, 28.17%), engenders technical difficulties (19 articles, 26.76%)—for both students (e.g., Al Nashash and Gunn, 2013) as well as instructors (e.g., Germany, 2012), falls flat due to students' reluctance to watch the lecture recordings (12 articles, 16.90%), attenuates instructor-student interaction (10 articles, 14.08%), and encourages surface learning and/or procrastination among students (9 articles, 12.68%).

Articles that feature in neither Appendix B nor Appendix C are those that fail to offer empirical support for any benefits or drawbacks of lecture capture. For example, Bollmeier et al. (2010) found no correlation between lecture capture usage and either attendance or academic performance. Even more recently, works such as Brackenbury (in press), Hadgu et al. (2016), as well as Sarsfield and Conway (2018) did not detect any relationship between lecture capture viewing and academic performance.

Table 1: List of benefits of lecture capture in higher education.

Benefits	Evident from number of articles (%)
Facilitates learning &/or revision	41 (57.75%)
Positively impacts academic performance	39 (54.93%)
Allows a better work-life balance	31 (43.66%)
Helps fill in lecture notes	21 (29.58%)
Aids revisiting difficult concepts	19 (26.76%)
Helps overcome language barriers	17 (23.94%)
Enhances student interest in lectures	10 (14.08%)
Supports students with disabilities	8 (11.27%)
Reduces anxiety among students	5 (7.04%)
Improves the quality of teaching	3 (4.22%)

Note. Percentages add to over 100 because one article could have found multiple benefits.

Table 2: List of drawbacks of lecture capture in higher education.

Drawbacks	Evident from number of articles (%)
Adverse impact on lecture attendance	20 (28.17%)
Tackling technical difficulties	19 (26.76%)
Students' reluctance to watch	12 (16.90%)
Attenuates instructor-student interaction	10 (14.08%)
Encourages surface learning &/or procrastination	9 (12.68%)
Instructors' discomfort &/or self-consciousness	7 (9.86%)

Note. Percentages add to over 100 because one article could have found multiple drawbacks.

Looking at the bigger picture, a conundrum is evident. On the one hand, students as research participants almost unanimously voice their support in favour of lecture capture, which they expect will facilitate learning as well as revision—particularly when difficult concepts are involved. These in turn, students believe, will have a positive impact on academic performance. On the other hand, instructors as research participants almost unanimously express concerns about waning attendance caused by lecture capture.

In other words, the assumption among most students is that lecture capture is helpful for learning, and among staff is that it takes a toll on attendance. This is why facilitation of learning and reduction in attendance emerged as the most widely documented benefit and drawback of lecture capture respectively.

However, research suggests that lecture capture, even if it facilitates learning and/or revision among students, does not always translate to better academic performance. Works such as Franklin et al. (2011) found students to believe that lecture capture improves grades, but no significant difference was detected in reality. Likewise, Marchand et al. (2014) found students to believe that lecture capture facilitates learning but instructors saw little impact on students' performance. In fact, Drouin (2014) as well as Edward and Clinton (2019) identified a negative relationship between lecture capture use and academic performance. Drouin (2014) further revealed that even though students had a positive attitude toward lecture

capture, they seldom viewed the actual lecture recordings. In addition, despite the general proclivity of the scholarly community to report only significant results and under-report those that are non-significant (Kerr, 1998; Yukhymenko, 2011), it is telling that several works have indicated a non-significant association between lecture capture viewing and academic performance (Bollmeier et al., 2010; Chapin, 2018; Euzent et al., 2011; Ford et al., 2012; Hadgu et al., 2016; Leadbeater et al., 2013; Mallinson and Baumann, 2015; Sarsfield and Conway, 2018; Traphagan et al., 2010).

With respect to lecture attendance, Leadbeater et al. (2013) confirmed a negative relationship even though students thought lecture capture would not affect their willingness to attend lectures. Similarly, according to Marchand et al. (2014), students believed that lecture capture would not affect their attendance but instructors noted increased absenteeism. Nevertheless, several works also reported non-significant relations between lecture capture and attendance (Baker et al., 2018; Bollmeier et al., 2010; Davis et al., 2009; Franklin et al., 2011; Groen et al., 2016; Gysbers et al., 2011McLean and Suchman, 2016; Nordmann et al., 2019; Shaw and Molnar, 2011; von Konsky et al., 2009; Wiese and Newton, 2013; Williams et al., 2016).

A possible way to reconcile the conundrum lies in finding ways to maximise the benefits of lecture capture while minimising its drawbacks as far as possible. To this end, a few works offered useful insights. Bos et al. (2016) showed that students often end up using lecture capture as a substitute for face-to-face lectures. This in turn takes a toll on lecture attendance. Edward and Clinton (2019) suggested that overreliance on lecture capture as a replacement for lecture attendance can be problematic for student learning. Lecture capture seems to breed a sense of dependence among students, who then start to undermine the value of attending the lectures face-to-face. Ominously, even low-performing students have been shown to rely on lecture capture as a substitute rather than a supplement to live lectures, thereby taking a toll on their attendance (Aldamen et al., 2015).

Nevertheless, according to Brooks et al. (2014), students who watched lecture recordings throughout the term outperformed those who did not. Sarsfield and Conway (2018) alluded to the fact that high-achieving students tend to view the recordings for learning whereas low-achieving students view only during the exam phase. Williams et al. (2012) found a positive correlation between lecture capture and academic performance, but it was evident only among students who also went to the lectures. Similarly, von Konsky et al. (2009) suggested that higher-achieving students have a proclivity to leverage both live and recorded lectures to reinforce their learning. According to Dommeyer (2017), lecture capture has a positive impact on academic performance but it works best when it supplements rather than replaces a lecture.

Interpreting these insights in conjunction with one another, lecture capture seems to work well if and only if students use the technology as a supplementary resource—rather than an alternative—to live lectures (Bos et al., 2016; Brooks et al., 2014; Dommeyer, 2017; Edward and Clinton, 2019; Sarsfield and Conway, 2018; von Konsky et al., 2009; Williams et al., 2012). It is probably time that this point is clearly communicated to students. Instructors have a huge role to play too. If they would like students to attend lectures as well as view the recordings, the course content should be strategically designed so that there is sufficient incentive on

both fronts. With academia almost en route to becoming netflixised, the reason why students should be attending the face-to-face sessions needs to be carefully thought through.

5. Conclusions

This paper sought to clarify the literature on the use of lecture capture in university higher education. A systematic literature review was conducted with 71 articles in the final sample. The findings suggest that most works focus on the US, the UK and Australia. The most studied STEM subject area in the sample is Biological Sciences. In contrast, the most studied non-STEM subject area is Business/Economics/Management. In terms of methods, descriptive and exploratory research dominates the research landscape while causative evidence is relatively limited. The literature includes two overarching research streams: While one focuses on the benefits of lecture capture, the other focuses on its drawbacks. The most widely documented benefit is that lecture capture facilitates learning, and the most widely documented drawback is that it hampers attendance in face-to-face lectures. The boundary of these findings is however limited to the commonly studied contexts of the US, the UK, and Australia—particularly for undergraduate students who study Biological Sciences and Business/ Economics/Management. Caution is advocated in generalising the findings beyond these boundary conditions.

By conducting a systematic review of lecture capture at a point in time when technology is increasingly infiltrating face-to-face lectures, the paper makes two key contributions. First, the critical insights that the review offers will enable educators to better understand how students use lecture capture. Instructors will have a richer understanding of how lecture capture is helpful on some fronts, and counter-productive on others. Instructors are urged to reflect on why students should be attending the face-to-face sessions, and thereafter also watch the recorded lectures (cf. Section 5.1 for detailed implications for practice).

Second, it contributes to the academic discussion on the use of lecture capture in higher education by identifying several under-investigated contexts (e.g., cross-country analysis), methods (e.g., experiments), and themes (e.g., instructors' lecture capture usage). With an attempt to shift existing paradigms, the paper hopes to ignite a body of research that can potentially reconcile students' perception of lecture capture, instructors' perception of lecture capture, and the reality of lecture capture (cf. Section 5.2 for detailed recommendations for future research).

These contributions, however, need to be viewed in light of the limitation that only articles in English were considered in this systematic review. Hence, the paper does not incorporate the essence of other works on lecture capture in institutions where the medium of instruction is not English, in which case the results stand a good chance to have been published in non-English outlets.

5.1. Implications for Practice

The paper has implications for teaching practices in university education. The systematic review offers a better understanding of how students use lecture capture than what any single empirical study would afford. As such, instructors and educators could use this understanding as a basis for a more effective integration of lecture capture in teaching. They could use the findings on what is helpful (cf. Table 1 and Appendix B) and what is counter-productive (cf. Table 2 and Appendix C) pertaining to the use of lecture capture to better utilise the technology as an educational resource.

Furthermore, students should be explicitly told about the benefits and the drawbacks of lecture capture. One cannot assume students to be aware of the best practice by default. It is the responsibility of instructors and educators to raise awareness among students that lecture capture needs to be utilised as a supplementary resource rather than an alternative to face-to-face lectures. This would ensure that they make the most of the technology while obviating its drawbacks. If students are required to attend face-to-face lectures and also watch the recordings for knowledge building, watching lecture capture might as well be added to their personalised timetables outside the face-to-face contact hours. This may offer them a sense of clarity and structure regarding what they should be doing with the recorded lectures.

For scholars to conduct lecture capture research using online logs, there are implications for lecture capture technology too. It is misleading that students who merely click on a link are considered to have accessed a lecture recording (Chapin, 2018). Perhaps, tools such as Panopto need to track the duration for which students are active and inactive. It could also capture which parts of the video are viewed once, which parts are viewed repeatedly, and which parts are skipped altogether. These will constitute useful data for future inquiry.

5.2. Recommendations for Future Research

The paper calls for further research to expand the contextual boundaries of the extant lecture capture literature beyond the US, the UK and Australia. This will help bring the literature more in line with the present trends of lecture capture usage worldwide, thereby bridging the literature-practice gap. More studies involving postgraduate students, executive students, and part-time students will also be helpful, particularly in subject areas that are currently under-represented in the literature (cf. Figure 4).

Where possible, lecture capture research needs to consider the perspectives of both students and staff in conjunction. This will help paint a more holistic picture and afford a greater degree of triangulation compared with current works, most of which myopically focus on only students (cf. Appendix A). For research involving staff, care should be taken to recruit not only junior academics but also experienced instructors—whose voices are not widely echoed in the current literature.

Research comparing data from multiple institutions is particularly recommended to better understand how lecture capture is received by a diverse range of students and staff, and whether any systematic differences exist as a function of contextual factors. For this purpose, cross-institutional collaborations among academics could be an ideal way forward. Cross-

national analysis has also been far and few hitherto. As indicated earlier, only one article reported a comparative analysis between two countries (Trenholm et al., 2019). Plugging this research gap may require wider cross-country collaborations among academics. In addition, works such as Bos et al. (2016) have made their data available under a Creative Commons BY-ND 3.0 licence. This could also be a step in the right direction in order to foster cross-country and cross-cultural lecture capture research. All in all, cross-institutional collaborations, cross-country collaborations, and open data sharing are poised to add a real impetus to the lecture capture research landscape, without which the question of how culture shapes lecture capture usage and attitudes will remain unanswered.

Moreover, scholars interested to publish empirical works in the field of lecture capture are urged to provide as much contextual details as realistically possible. Peer-reviewers of journals too have a crucial role to play as gatekeepers. Since the field is very much sensitive to contextual factors (Caglayan and Ustunluoglu, in press; Nordmann et al., 2019), lack of sufficient details thwarts a systematic interpretation of the results. For example, several articles in the systematic review did not specify the duration of lecture recordings, the number of lectures or the shape of the academic year (e.g., semester or trimester), and undergraduate student categorisation by year of study where applicable. Findings cannot be assumed to be the same regardless of such factors. In fact, these might as well moderate the relation between lecture capture usage and academic performance as well as that between lecture capture usage and attendance—a significant omission in the current literature that warrants scholarly attention.

As technology continues to evolve and students keep on adapting, this paper recognises a need for replication in lecture capture research, especially the quantitative studies with small sample size. Currently, owing to the relatively limited number of studies with little methodological consistency—that too with occasionally insufficient contextual details, the true picture of lecture capture remains blurred. In this vein, both close replication and differentiated replication could be pursued (Uncles and Kwok, 2013). Close replication facilitates verifying previous results in almost similar settings. Differentiated replication allows for variations at conceptual, methodological and/or substantive levels to test the generalisability of previous results.

Such replications should be situated within broader pedagogical theories and frameworks. This is important because existing works mostly present descriptive and/or exploratory research fuelled by practical concerns rather than theoretical debates. The literature will be enriched by an understanding of lecture capture through the lenses of various learning paradigms such as behaviourism, cognitivism and constructivism (Bichelmeyer and Hsu, 1999; Ertmer and Newby, 1993; Radianti et al., 2020).

Furthermore, the replications should control for all possible contextual factors that the original studies might have missed out. Even if the replications yield statistically non-significant results, they should not be treated as theoretically insignificant. Otherwise, the practice of reporting only significant results will never allow the true picture of lecture capture to emerge.

Given the often-held apprehension that journals are hesitant to publish sole replications, scholars are encouraged to augment the replicative efforts with additional studies to pass muster. On the quantitative front, experimental research is encouraged so as to obtain causative evidence. Big data analyses and computational techniques could be explored too. If algorithms can predict academic performance from lecture capture usage, it would be a helpful tool for educators to identify at-risk students on the fly and support them accordingly.

On the qualitative front, more in-depth interviews could be conducted. Emerging data collection approaches such as screencast videography could be employed to better appreciate students' lived digital experience of viewing lecture recordings (Kawaf, 2019). Nuances could be teased out between when lecture recordings are watched on laptops versus mobile devices. Differences between lower-achieving and higher-achieving students as well as those between frequent attendees and non-frequent attendees are worth investigating. At the undergraduate level, longitudinal studies—either quantitative or qualitative—will also be useful to shed light on how students mature from their first year of study to the final year.

Furthermore, the paper calls for more lecture capture research involving instructors. Here are a few possible research questions that are under-explored thus far: To what extent do instructors utilise lecture capture to reflect on their teaching practices? How does instructors' teaching performance (e.g., student feedback as proxy variable) with lecture capture differ from that without lecture capture? In what ways do instructors' use of lecture capture for teaching purposes evolve over time? How does instructors' lecturing style, personality and other individual differences affect their teaching performance as well as students' lecture capture usage? Are there any differences in attitudes toward lecture capture between junior and senior academics, given that the latter lies relatively more toward the wrong side of the digital divide? To what extent do instructors' teaching performance and students' lecture capture usage vary when the technology captures only audio versus both audio and video? In what ways do instructors' and students' use of lecture capture differ when the technology is rolled out under regulatory pressure versus when it is embraced voluntarily? By identifying these research opportunities, the paper hopes to pave the way to reconcile students' perception of lecture capture, instructors' perception of lecture capture, and the reality of lecture capture. Table 3 summarises the dominant research trends and the future research directions in light of the three objectives that this systematic review sought to achieve.

Finally, as the COVID-19 pandemic and the social distancing measures continue to accelerate the push toward online teaching and learning, how instructors and students adapt their use of lecture capture—both in vitro and in vivo (Pale et al., 2014)—is worth investigating. Instructors, who were once reluctant to adopt lecture capture, may become more open to using the technology. Students' attitudes, motivations, and behavioural engagement may also change in unprecedented ways. To better understand the educational upheaval linked with the pandemic, pre- versus mid- versus post-COVID-19 comparative studies on lecture capture are essential. This could be a particularly exciting research direction among scholars who have already accumulated a wealth of data prior to the COVID-19 outbreak.

Table 3: Current trends and future directions in lecture capture research in higher education.

	Dominant Research Trends	**Future Research Directions**
Objective 1: Contexts	• Country: US, UK, Australia • Sample: Undergraduate students • Discipline: Biological Sciences, Business/ Economics/ Management	• Research on under-investigated countries, samples and disciplines • Comparison of data from multiple institutions • Cross-country and cross-cultural study • Jointly understanding the views of students and instructors
Objective 2: Methods	• Mixed methods • Surveys and tracking student-specific data • Correlational research • Exploratory research	• Causative research (e.g., experiments) • Big data analyses • Interviews and screencast videography • Longitudinal study • Theory-driven research
Objective 3: Overarching Steams in the Literature	• Positive association with learning but negative association with attendance • Benefits of lecture capture seem to outnumber its drawbacks • The assumption among most students is that lecture capture is helpful for learning, and among staff is that it takes a toll on attendance • Lecture capture seems to work well if students use it as a supplementary resource—rather than an alternative—to live lectures	• Close and differentiated replication • Comparing students watching on laptops versus mobile devices • Comparing usage between lower-achieving and higher-achieving students • Comparing usage between frequent attendees and non-frequent attendees in face-to-face lectures • Research on instructors' personality, lecturing style, and teaching performance with and without lecture capture • Comparing junior and senior academics as instructors when using lecture capture • Reconciliation of students' perception of lecture capture, instructors' perception of lecture capture, and the reality of lecture capture

Note. For all future research, scholars are encouraged to provide as much contextual details as possible. Such factors including the likes of duration of lecture recordings, number of lectures recorded, availability of lecture capture, year of study for undergraduate students, availability of captions in the recordings, etc. can even be used as potential moderating variables.

5.3. Concluding Remarks

To conclude, while the issues raised by lecture capture are complex, the researcher would like to argue that its benefits (cf. Appendix B) outweigh its drawbacks (cf. Appendix C). Nevertheless, students need to be explicitly told how to make the best use of lecture capture. In addition, instructors need to plan content and delivery in such a way so that either of lecture attendance or lecture capture viewing cannot steal the thunder from each other.

That said, the paper invites interested scholars to challenge this argument forwarded by the researcher. In the wake of the COVID-19 outbreak, if it manages to stir a healthy debate among the scholarly community regarding the use of lecture capture in universities, it would have served its purpose.

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Appendix A

Table A.1: Lecture capture research contexts and research methods.

Article	Site of Research	Sample		Academic Discipline		Methodology	
		Student / Staff	UG/PG Student	General Subject Area	STEM (= 1)	Qual/ Quant	Data (Size if available)
Al Nashash and Gunn, 2013	UAE	Student	Not specified	Engineering	1	Mixed	Survey (38) + FGD (4) + Tracking student data (40)
Aldamen et al., 2015	Qatar	Student	UG	Business / Economics / Management	0	Quant	Survey (254) + Tracking student data (254)
Baker et al., 2018	Australia	Student	PG	Biological Sciences	1	Quant	Survey (88) + Tracking student data (453)
Bollmeier et al., 2010	US	Student	UG	Biological Sciences	1	Quant	Survey (122) + Tracking student data
Bos et al., 2016	Netherlands	Student	UG	Biological Sciences	1	Quant	Tracking student data (396)
Brackenbu-ry, in press	UK	Student	UG	Biological Sciences	1	Quant	Tracking student data (763)
Brady et al., 2013	Canada	Student	UG	Biological Sciences	1	Quant	Survey (77) + Tracking student data
Brooks et al., 2014	Canada[3]	Student	UG	Sciences	1	Quant	Tracking student data (1,379)
Caglayan and Ustunluoglu, in press	Turkey	Student	UG + PG + Associate	Mixed	N/A	Quant	Tracking student data (7,547)
Chapin, 2018	Australia	Student	UG	Biological Sciences	1	Mixed	Survey (71)
Chen and Lin, 2012	Taiwan	Student	UG	Business / Economics / Management	0	Quant	Survey (312) + Tracking student data (312)
Cooke et al., 2012	Australia	Student	UG	Biological Sciences	1	Quant	Survey (128)
Danielson et al., 2014	US	Both	UG	Biological Sciences	1	Mixed	FGD (23) + Survey (257) + Tracking student data (491)

Article	Site of Research	Sample		Academic Discipline		Methodology	
		Student / Staff	UG/PG Student	General Subject Area	STEM (= 1)	Qual/ Quant	Data (Size if available)
Davis et al., 2009	UK	Student	UG	Engineering	1	Mixed	Survey (120) + FGD (5)
Dommett et al., 2019[1]	UK	Both	UG + PG	Mixed	N/A	Mixed	Survey (617) + FGD (25)
Dommeyer, 2017	US[3]	Student	UG	Business / Economics / Management	0	Quant	Experiment (84)
Dona et al., 2017	Australia	Both	UG + PG	Mixed	N/A	Mixed	Survey (119) + Interview (119)
Draper et al., 2018	UK	Both	UG	Law	0	Mixed	Survey (60) + Tracking student data (60)
Drouin, 2014	US	Student	UG	Biological Sciences	1	Quant	Experiment (141) + Tracking student data (141)
Ebbert and Dutke, 2020	Germany	Student	Not specified	Mixed	N/A	Quant	Survey (1,079)
Edwards and Clinton, 2019	UK	Student	UG	Business / Economics / Management	0	Quant	Experiment (321)
Elliot and Neal, 2016	UK	Student	UG	Business / Economics / Management	0	Mixed	Tracking student data (1439)+ Survey (216)
Euzent et al., 2011	US	Student	UG	Business / Economics / Management	0	Quant	Survey + Tracking student data
Farooq et al., 2017[1]	Malaysia	Student	Exec-utive	Business / Economics / Management	0	Quant	Survey (481)
Ford et al., 2012	US	Student	UG	Biological Sciences	1	Quant	Experiment (119)
Franklin et al., 2011	US	Student	UG	Biological Sciences	1	Quant	Survey (206) + Tracking student data (206)
Freed et al., 2014	US	Staff	N/A	Biological Sciences	1	Qual	FGD (14)
Germany, 2012	Australia	Staff	N/A	Mixed	N/A	Mixed	FGD (10) + Survey (96)
Gorissen et al., 2012[1]	Netherlands	Student	UG	Biological Sciences	1	Mixed	Survey (517) + Interview (14)

Article	Site of Research	Sample		Academic Discipline		Methodology	
		Student / Staff	UG/PG Student	General Subject Area	STEM (= 1)	Qual/ Quant	Data (Size if available)
Gorissen et al., 2013[1]	Netherlands	Student	Not specified	Mixed	N/A	Mixed	Survey (120) + Interview (14)+ Tracking student data
Gorissen et al., 2015	Netherlands	Student	Not specified	Engineering	1	Quant	Experiment (255) + Tracking student data (255)
Gosper et al., 2010[1]	Australia	Both	UG + PG	Mixed	N/A	Mixed	Survey (970) + Interview (16)
Groen et al., 2016	Canada	Both	Not specified	Mixed	N/A	Mixed	Survey (1145) + Interview (6) + FGD (11) + Tracking student data (775)
Gupta and Saks, 2013	US	Student	UG	Biological Sciences	1	Mixed	Survey (213)
Guy et al., 2018	Australia[3]	Student	UG	Biological Sciences	1	Quant	Survey (137)+ Tracking student data (137)
Gysbers et al., 2011	Australia	Both	UG	Biological Sciences	1	Mixed	Survey (593)
Hadgu et al., 2016	US	Student	UG	Biological Sciences	1	Quant	Tracking student data (63)
Hall and Ivaldi, 2017	UK	Student	UG	Mixed	N/A	Qual	FGD (42)
Hussain et al., 2018	UK	Student	Not specified	Biological Sciences	1	Quant	Survey (105)
Jones and Olczak, 2016	UK	Student	UG	Business / Economics / Management	0	Quant	Tracking student data (380)
Joseph-Richard et al., 2018	UK	Staff	N/A	Mixed	N/A	Mixed	Survey (46) + Interview (12)
Khan, 2016	Qatar	Student	UG	Business / Economics / Management	0	Mixed	Survey (97) + Tracking student data (124)
Krautscheid et al., in press	US	Student	UG	Mixed	N/A	Qual	FGD (23)

Article	Site of Research	Sample		Academic Discipline		Methodology	
		Student / Staff	UG/PG Student	General Subject Area	STEM (= 1)	Qual/ Quant	Data (Size if available)
Lambert et al., in press	UK	Student	UG	Business / Economics / Management	0	Mixed	Survey (64) + Tracking student data (64)
Leadbeater et al., 2013	UK	Student	UG	Biological Sciences	1	Mixed	Survey (140) + Tracking student data + FGD (10)
Luttenberger et al., 2018	Austria[3]	Student	Not specified	Education	0	Quant	Survey (611)
MacKay, in press	UK	Both	UG	Mixed	N/A	Qual	Interview (13) + Survey (295) + FGD (2)
Mallinson and Baumann, 2015	US	Student	UG	Political Science	0	Mixed	Survey (320) + Tracking student data (320)
Marchand et al., 2014	Canada	Both	UG	Biological Sciences	1	Mixed	Survey (273) + Tracking student data
McCunn and Newton, 2015	Canada	Student	UG	Biological Sciences	1	Quant	Survey (87) + Tracking student data (87)
McLean and Suchman, 2016	US	Student	UG	Biological Sciences	1	Quant	Experiment + Tracking student data (1,014)
Nair et al., 2015	Malaysia	Student	UG	Mixed	N/A	Quant	Survey (398)
Nightingale et al., 2019[1]	UK	Student	UG	Biological Sciences	1	Mixed	Experiment (92) + FGD (92)
Nordmann et al., 2019	UK	Student	UG	Biological Sciences	1	Quant	Tracking student data (290)
O'Brien and Verma, 2019	Australia[3]	Student	UG	Business / Economics / Management	0	Quant	Tracking student data (1,169)
Owston et al., 2011	Canada	Student	UG	Biological Sciences	1	Quant	Survey (439)
Rahman et al., 2018	Australia	Both	UG	Engineering	1	Mixed	Survey (105) + Tracking student data
Sarsfield and Conway, 2018	UK	Student	UG	Sciences	1	Quant	Tracking student data

Article	Site of Research	Sample		Academic Discipline		Methodology	
		Student / Staff	UG/PG Student	General Subject Area	STEM (= 1)	Qual/ Quant	Data (Size if available)
Saunders and Hunt, 2015	UK	Student	PG	Business / Economics / Management	0	Mixed	Survey (84) + FGD (15)
Shaw and Molnar, 2011	US	Student	UG	Biological Sciences	1	Quant	Experiment (113)
Sloan and Lewis, 2014	US	Student	UG	Business / Economics / Management	0	Quant	Tracking student data (70)
Taplin et al., 2011	Australia	Student	UG + PG	Business / Economics / Management	0	Mixed	Survey (211)
Terry et al., 2015	US	Student	UG	Business / Economics / Management	0	Quant	Tracking student data (890)
Traphagan et al., 2010	US	Student	UG	Geology	1	Mixed	Experiment (364) + Tracking student data
Trenholm et al., 2019[1,2]	UK, Australia	Student	UG	Mathematics	1	Quant	Experiment (93)
von Konsky et al., 2009	Australia	Student	UG	Computer / Information Science	1	Quant	Survey (108) + Tracking student data (108)
Wiese and Newton, 2013	Canada	Student	UG	Biological Sciences	1	Quant	Survey (308)+ Tracking student data (597)
Williams et al., 2012	Australia	Student	UG	Business / Economics / Management	0	Quant	Survey (371) + Tracking student data (371)
Williams et al., 2016	US	Student	UG	Biological Sciences	1	Quant	Tracking student data (835)
Yeung et al., 2016	Australia	Student	UG	Biological Sciences	1	Mixed	Survey (1,022)
Yu et al., 2015	Taiwan	Student	UG	Computer / Information Science	1	Quant	Experiment (302)

Notes. 1 = More than one institute involved.
2 = More than one country involved.
3 = Site not explicitly specified but inferred from the author(s)' affiliation.
FGD = Focus group discussion.
STEM = Science, Technology, Engineering and Mathematics Subject.
The last column indicates the number of data points within parentheses for each data source, provided it was clearly indicated.

Appendix B

Table B.1: Benefits of lecture capture in higher education.

Article	Facilitates learning &/or revision	Positively impacts academic performance	Allows a better work-life balance	Helps fill in lecture notes	Aids revisiting difficult concepts	Helps overcome language barriers	Enhances student interest in lectures	Supports students with disabilities	Reduces anxiety among students	Improves the quality of teaching
Al Nashash and Gunn, 2013	x	x	x	x	x		x			
Aldamen et al., 2015[2]	x	x	x		x		x			
Baker et al., 2018[1]	x	x								
Brooks et al., 2014		x								
Caglayan and Ustunluoglu, in press	x	x	x							
Chapin, 2018	x	x	x		x	x				
Chen and Lin, 2012[2]		x								
Cooke et al., 2012[1]	x		x							
Danielson et al., 2014[1]		x				x	x			
Davis et al., 2009	x		x	x	x					
Dommeyer, 2017[2]	x	x	x						x	
Dona et al., 2017	x	x	x	x	x	x				
Draper et al., 2018	x	x	x	x						
Ebbert and Dutke, 2020	x	x	x				x			
Elliot and Neal, 2016[2]	x	x		x	x			x		
Euzent et al., 2011[2]	x	x	x							
Ford et al., 2012[1]	x									

Article	Facilitates learning &/or revision	Positively impacts academic performance	Allows a better work-life balance	Helps fill in lecture notes	Aids revisiting difficult concepts	Helps overcome language barriers	Enhances student interest in lectures	Supports students with disabilities	Reduces anxiety among students	Improves the quality of teaching
Franklin et al., 2011[1]		x	x	x	x				x	
Gorissen et al., 2012[1]	x	x	x	x		x				
Gorissen et al., 2013	x	x	x	x		x	x			
Gorissen et al., 2015	x	x		x						
Gosper et al., 2010	x	x	x	x	x	x		x		
Groen et al., 2016	x	x	x	x	x	x			x	
Gupta and Saks, 2013[1]	x	x	x		x					
Guy et al., 2018[1]		x								
Gysbers et al., 2011[1]	x		x	x	x	x				x
Hall and Ivaldi, 2017	x		x	x		x		x		
Hussain et al., 2018[1]	x	x	x	x	x					
Jones and Olczak, 2016[2]	x	x								
Joseph-Richard et al., 2018										x
Krautscheid et al., in press	x	x		x			x	x		
Lambert et al., in press[2]	x	x	x	x		x	x	x		

Article	Facilitates learning &/or revision	Positively impacts academic performance	Allows a better work-life balance	Helps fill in lecture notes	Aids revisiting difficult concepts	Helps overcome language barriers	Enhances student interest in lectures	Supports students with disabilities	Reduces anxiety among students	Improves the quality of teaching
Leadbeater et al., 2013[1]			x	x	x	x		x		
Luttenberger et al., 2018		x								
MacKay, in press	x		x		x		x	x		
Mallinson and Baumann, 2015	x		x		x	x				
Marchand et al., 2014[1]	x	x	x	x	x		x			
McCunn and Newton, 2015[1]					x					
McLean and Suchman, 2016[1]	x			x					x	
Nightingale et al., 2019[1]	x			x			x	x		
Nordmann et al., 2019[1]		x								
O'Brien and Verma, 2019[2]			x							
Owston et al., 2011[1]	x									
Rahman et al., 2018	x	x	x		x	x				x
Saunders and Hunt, 2015[2]	x		x			x				
Shaw and Molnar, 2011[1]		x				x				

Article	Facilitates learning &/or revision	Positively impacts academic performance	Allows a better work-life balance	Helps fill in lecture notes	Aids revisiting difficult concepts	Helps overcome language barriers	Enhances student interest in lectures	Supports students with disabilities	Reduces anxiety among students	Improves the quality of teaching
Sloan and Lewis, 2014[2]		x								
Taplin et al., 2011[2]	x	x								
Terry et al., 2015[2]										
Traphagan et al., 2010	x	x	x						x	
von Konsky et al., 2009	x									
Wiese and Newton, 2013[1]	x	x								
Williams et al., 2012		x								
Williams et al., 2016[1]	x	x	x			x				
Yeung et al., 2016[1]	x	x	x	x	x	x				
Yu et al., 2015	x	x								
Total	**41**	**39**	**31**	**21**	**19**	**17**	**10**	**8**	**5**	**3**

Notes. 1 = Biological Sciences, the most widely studied STEM subject area.

2 = Business/ Economics / Management, the most widely studied non-STEM subject area.

Appendix C

Table C.1: Drawbacks of lecture capture in higher education.

Article	Adverse impact on lecture attendance	Tackling technical difficulties	Students' reluctance to watch	Attenuates instructor-student interaction	Encourages surface learning &/or procrastination	Instructors' discomfort &/or self-consciousness
Al Nashash and Gunn, 2013		x	x			
Aldamen et al., 2015[2]	x					
Bos et al., 2016[1]	x					
Brady et al., 2013[1]			x			
Chapin, 2018[1]		x	x			
Cooke et al., 2012[1]		x		x		
Danielson et al., 2014[1]	x			x		x
Davis et al., 2009	x	x	x			
Dommett et al., 2019						x
Dommeyer, 2017[2]		x		x		
Dona et al., 2017	x	x	x	x	x	x
Drouin, 2014[1]	x					
Ebbert and Dutke, 2020	x					
Edwards and Clinton, 2019[2]	x				x	
Elliot and Neal, 2016[2]		x				
Euzent et al., 2011[2]	x					
Farooq et al., 2017[2]		x				
Franklin et al., 2011[1]		x				
Freed et al., 2014[1]	x				x	x

Article	Adverse impact on lecture attendance	Tackling technical difficulties	Students' reluctance to watch	Attenuates instructor-student interaction	Encourages surface learning &/or procrastination	Instructors' discomfort &/or self-consciousness
Germany, 2012		x				
Gorissen et al., 2012[1]		x	x			
Gosper et al., 2010	x	x		x		x
Groen et al., 2016		x	x			
Gysbers et al., 2011[1]		x		x	x	
Hall and Ivaldi, 2017	x		x		x	
Hussain et al., 2018[1]			x			
Joseph-Richard et al., 2018						x
Khan, 2016[2]		x				
Leadbeater et al., 2013[1]	x				x	
Luttenberger et al., 2018	x					
MacKay, in press		x			x	x
Mallinson and Baumann, 2015		x	x			
Marchand et al., 2014[1]	x					
McCunn and Newton, 2015[1]					x	
Nair et al., 2015		x				
Nightingale et al., 2019[1]				x		

Article	Adverse impact on lecture attendance	Tackling technical difficulties	Students' reluctance to watch	Attenuates instructor-student interaction	Encourages surface learning &/or procrastination	Instructors' discomfort &/or self-consciousness
Owston et al., 2011[1]	x					
Rahman et al., 2018	x			x		
Saunders and Hunt, 2015[2]		x				
Taplin et al., 2011[2]	x		x			
Traphagan et al., 2010	x					
Trenholm et al., 2019	x			x	x	
Williams et al., 2016[1]			x			
Yeung et al., 2016[1]				x		
Total	**20**	**19**	**12**	**10**	**9**	**7**

Notes. 1 = Biological Sciences, the most widely studied STEM subject area.

2 = Business/ Economics / Management, the most widely studied non-STEM subject area.