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Developing the inclusive curriculum: Is supplementary lecture recording an effective approach in supporting students with Specific Learning Difficulties (SpLDs)?

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**Developing the inclusive curriculum: Is supplementary lecture recording an effective approach in supporting students disclosing dyslexia?**

**Abstract**

Supplementary lecture capture is widely used in higher education as the recordings generated are highly valued by students. Here we used a between-subjects, mixed methods study to evaluate whether this approach can support the learning of students disclosing *Specific Learning Difficulties* (SpLDs). We used a '*Lecture – Independent study – Exam'* design, and two groups of students: (i), 42 participants disclosing dyslexia, and (ii), 50 students with no disclosed SpLDs, to assess the impact of studying with lecture recordings on academic performance.

We show that independent study with a lecture recording is as effective as studying with a textbook in supporting academic performance. Importantly, both groups of students performed equally, despite the barriers that lectures present for many disclosing dyslexia. These students suggested that lecture recordings compensated for these difficulties due to their on-line availability, engaging format and ability to support a range of learning approaches. We conclude that lecture recordings are an effective way to support students disclosing dyslexia and other SpLDs, and have a role to play in inclusive curricula.

**1.0 Introduction**

One of the strengths of higher education is its diversity, reflecting the expanding proportion of the population that attends university, and the variety of the student cohort. However, this places responsibility on the sector to develop learning environments that enable all students to achieve their potential. Here we focus on students who disclose Specific Learning Difficulties (SpLDs), to understand the effectiveness of supplementary lecture recording in supporting learning.

Students that disclose SpLDs represent a large and increasing proportion of the undergraduate cohort in the UK (~6% of UG cohort, HESA, 2014-15), perhaps reflecting an increased awareness of these conditions in the population and enhanced support within HE institutions. Of these, a large proportion disclose dyslexia, which has been defined as '*a learning difficulty that primarily affects the skills involved in accurate and fluent word reading and spelling*' (Rose, 2009). These students often face difficulties with a range of academic writing skills (Mortimore & Crozier, 2006), including note-taking in lectures (Fuller et al., 2004), frequently reflecting problems in handwriting fluency, spelling (Conelley et al., 2006), and the speed of lecture delivery

(Boyle et al., 2015). Note-taking is a crucial skill for academic success (Einstein et al., 1985), and may partially explain the poorer progression and 'achievement gaps' observed in students disclosing this condition (Richardson & Wydell, 2003; Richardson, 2010), although confounding factors (*e.g. student gender, lower entry qualifications*) may explain this under-performance (Richardson, 2009).

Developing inclusive approaches that can accommodate the diversity in student cohorts is challenging, particularly in STEMM disciplines (e.*g. Science, Technology, Engineering, Maths, Medicine*), which use specialised vocabularies and/or scientific notation, and often involve learning detailed material in lecture based, high contact curricula. In this context, recommendations for inclusive practice (*e.g. Supporting STEM students with dyslexia, Institute of Physics, 2013),* typically propose 'universal design' principles that accommodate *all* students' needs (Mcguire et al., 2006).

In this study, we seek to understand whether supplementary lecture capture can support inclusive learning. This approach involves the use of multimedia recordings (typically an audio recording and associated PowerPoint slides) as supplementary learning materials, which students access online via a *Virtual Learning Environment*. Numerous studies have demonstrated that these materials are highly valued by students, reflecting their engaging audio-visual format, ability to support flexible and/or distance learning (Soong et al., 2006), and because they allow students to learn at their own pace (Bassili & Joordens, 2008). Students often adopt a 'targeted' or strategic approach to these materials, revisiting specific slides (i), where they experienced difficulties, or were unable to attend the session, or (ii), for pre-exam revision (Williams & Fardon, 2007). This is consistent with download analysis (Elliott & Neal, 2016), which suggests that students adopt a variety of approaches to these materials (von Konsky et al., 2009). Interestingly, detailed analysis suggests that only students that use recordings *regularly* show a significant increase in grades, (Brooks et al., 2014), suggesting that a consistent approach to study, and effective note-taking (McKinney et al., 2009), are important for academic performance with these materials. In contrast to this broad understanding of students' use of recordings, the potential of lecture recordings to contribute to inclusion is largely unexplored. Observations that low achieving students use recordings more (McNulty et al., 2009; Le et al., 2010; Owston et al., 2011), in common with  those from non-English speaking backgrounds, or those that disclose dyslexia (Leadbeater et al., 2013) suggest that they address the specific academic difficulties of these students (Olofsson et al., 2012; Pearce & Scutter, 2010).

This study is based on an understanding that a substantial proportion of students (including the majority of those disclosing dyslexia) experience problems taking notes in lectures, and that this impacts on their academic performance. We hypothesised that lecture recordings could compensate for these difficulties by allowing students to improve their lecture notes and/or revise, and that this would lead to measurable increases in learning. We describe a between-subjects study using a *'Lecture – Revise – Exam'* design*,* to

evaluate whether supplementary lecture capture can support students' learning and increase their academic performance. We compare two student groups; (i) those that disclose dyslexia, and (ii) those with no disclosed learning difficulties (e.g. as a 'Control' group), and use quantitative and qualitative methods to understand students' experience of learning in lectures, and whether lecture recording can overcome the barriers of this format.

## 2.0 Materials and methods.

This study used a mixed methods design to compare the impact of independent study using either a lecture recording (or a textbook as a 'control'), on the academic performance of students either disclosing dyslexia, or with no disclosed SpLDs. The details of the participants, study design, data collection methods and analysis are outlined below.

## 2.1 Terminology

We recognise the need to use appropriate terminology for study participants and have engaged with the challenges surrounding this (Evans, 2014). Here we refer to our participants as '*Disclosing dyslexia'* or as a *'Control'* group, '*With no disclosed SpLDs',* in line with practice elsewhere in the literature.

## 2.2 Participants

This study recruited participants studying at different points (Yrs. 1, 2 & 3), in a variety of undergraduate programmes within the biological sciences (*e.g. Medicine, Pharmacy, Psychology, Diatetics, Midwifery, Nursing, Biochemistry).* Students were recruited from three universities based in the West Midlands (*Birmingham, Birmingham City & Coventry University*), with the majority of participants disclosing dyslexia recruited via *Learning Support* teams (indicating that they had disclosed their SpLD status to the institution), whereas those without disclosed SpLDs were recruited from comparable biological science programmes. Participants were paid staged incentives for attending the study, with £20 (ca US $26) for attending Stage 1, and a further £30 (ca US $39) for attending Stage 2.

We initially recruited 56 students disclosing dyslexia and 72 with no disclosed SpLDs, of which 42/56 and 50/72 attended the second study session (Fig 1. Stage 2). The data from six students were excluded as they were from inappropriate disciplinary backgrounds. Six participants that identified as dyslexic also disclosed other condition(s) that impacted on learning, consistent with findings that dyslexia is frequently found in

combination with ADHD, dyscalculia or dyspraxia (Ramus, 2004). The gender balance of participants was heavily skewed in both groups (*No disclosed SpLDs*: female 77%: male: 23%; *Disclosing dyslexia*: female 88%: male 12%), possibly reflecting the female bias of the programmes targeted. The majority of participants were 18–21 years old (82%), with a small number of older participants (22-30 years: 13%; Over 30 years: 5%).

All participants were anonymized by the allocation of an identification number when registering for the study, and this was attached to all quantitative data collected, allowing the investigators to link students with their questionnaire responses and exam marks.

**2.3 Study design and data analysis**

This study focussed on the use of supplementary lecture recordings, and whether this is an effective approach to support inclusive learning. As such, we used a design based upon a typical higher education learning environment (*e.g. lecture – independent study – exam*), to assess whether studying with a lecture recording could impact on performance in a multiple choice question-based exam a month after the lecture. As we were interested in comparing study with lecture recordings with typical current practice, half of the participants were randomly allocated to a group where their study was supported with an appropriate section of a textbook. The design of the study, and the types of data collected are summarised below (Fig. 1).

**SUGGESTED FIG 1 HERE**

Fig. 1. Study design, including the points at which data were collected. Participants were recruited at *Stage 1*, where a short multiple choice question-based exam was administered (*MCQ Exam 1*), prior to the lecture. Participants were randomly assigned to one of two groups who were asked to study with either a textbook or lecture recording, prior to *Stage 2*, approximately four weeks later, where they were re-examined on the lecture topic (*MCQ Exam 2*). During this session, participants were asked to complete a questionnaire about their study methods, and participate in focus groups.

*(i) Lecture, independent study and exam design, including analysis of academic performance.*

The lecture was designed to replicate typical HE experience, in that it was ~50 minutes long, was supported with a 'handout' of the lecture slides, and covered a topic that the majority of the students were unlikely to be familiar with ('*Beyond DNA: An introduction to epigenetics*'). Students were asked to take notes, and to study at home as they would for an exam on their programme. Immediately after the session, participants

were randomly allocated to two groups and given access to either a website with the lecture recording, or sent an electronic copy of the appropriate section of a molecular biology textbook.

Previous studies evaluating whether *audio-only* recordings could support students disclosing dyslexia used a '*Pre-lecture exam – Lecture – Study - Final exam*' design to assess any changes in academic performance (Beacham & Alty, 2006). Given the heterogeneity of our study participants, we used the same approach to accommodate the variability in educational backgrounds, using a multiple choice question exam before the lecture (*Fig 1. MCQ Exam 1*), to assess any prior knowledge and establish a baseline, so that learning could be assessed at a second exam after the lecture and revision (*Fig. 1. MCQ Exam 2*). Both exams were short (i.e. *20 questions, ~30 min. duration*), and assessed similar themes so performance could be compared. Crucially, a questionnaire surveyed how long participants had studied for the exam, allowing us to identify those that did not revise, and analyse their exam performance separately. Changes in participants' performance in the two exams (e.g. marks in MCQ exam 2 – marks in MCQ exam 1), were analysed by SPSS, and 2-tailed T-tests performed to assess the significance of any changes, including any differences between participants who studied with lecture recordings or textbooks.

(ii) *Questionnaire design and analysis*

We used a short questionnaire to survey students' characteristics (e.g. gender, age, SpLD status); their attitudes and responses to the lecture format, supplied learning material (e.g. textbook, lecture recording), and the extent to which they engaged with these materials. Several questions developed in an earlier study (Leadbeater et al., 2013), were included to survey whether participants experienced problems taking notes in lectures, and the approaches used (if any) to compensate for these difficulties. Responses were analysed by SPSS and presented graphically.

*(iii) Focus groups and qualitative data analysis*

Focus groups took a semi-structured approach using questions that centred on students' views of learning from lectures; the difficulties (if any) that they experienced, and any strategies they used to compensate. Questions also focussed on students' independent learning and their perception(s) of text-based or audio-visual learning materials. Discussions lasted for ~40 minutes, typically involved 6-8 participants, and were divided into students with no disclosed SpLDs (5 focus groups) or those disclosing dyslexia (6 focus groups) to identify any differences in responses. Interviews were facilitated by several researchers to minimise the impact of interviewer bias. Focus groups were recorded, and transcripts analysed to identify common themes and sub-themes for the two groups using a structured approach to thematic analysis (Braun &

Clarke, 2006). This involved a staged process, where after (i) initial familiarization with the transcripts and systematic coding of interesting features across the data set, (ii) coded material was collated into potential themes. At this point, (iii) themes were reviewed to ensure they encapsulated the coded features, and a 'thematic map' created. Finally (iv) the themes were defined, prior to being summarised in a report.

## 2.4 Ethics and study funding

The study was performed in line with *British Educational Research Association* guidelines, with ethical approval given by the University of Birmingham STEM Ethical Review Committee. Participants were asked to review a '*Participants Information Sheet'* and give informed consent prior to recruitment to the study and focus group participation. The study was co-funded by the University of Birmingham's *Centre for Learning & Development* and an *Echo360 Active Learning Grant*. Funders had no influence on the study design, data interpretation or publication.

## 3.0 Results

This study aimed to evaluate whether supplementary lecture recording can support the learning of students that disclose dyslexia. This was assessed by analysing participants' academic performance in a typical HE context (*e.g. Lecture - Study – Exam,* Part 3.1), but also by the use of questionnaires to survey students' experience of lectures (Part 3.2). Finally, we used focus groups and thematic analysis (Part 3.3) to gain an understanding of students' perceptions of the lecture format, and whether supplementary recordings can address the barriers many students experience in these sessions.

### *3.1 Independent study with lecture recordings can support students' academic performance.*

Our initial focus was to assess whether independent study with either a supplementary lecture recording (or a textbook, as a comparison) could increase the academic performance of students disclosing dyslexia, using students with no disclosed SpLDs as a comparative 'control'. Given the diversity of the study participants, we used a '*Pre-lecture exam – Lecture - Study – Final exam*' design to evaluate changes academic performance, and accommodate variation in participant's prior knowledge of the lecture topic (Fig. 1.). This allowed us to define two important aspects of the study participants.

*(1) Baseline data on prior knowledge of topic (MCQ Exam 1)*
Marks in the pre-lecture exam (MCQ Exam 1, Fig. 1, *Before lecture*) showed no significant difference between the two groups of students (Fig. 2, Upper panel: *Control / No disclosed SpLDs.* Mean mark = 30.7 $^+/_-$ 16.1%, *Disclosed dyslexia.* Mean mark = 33.4 $^+/_-$ 18.2%; 2-tailed T-test, *p*=0.359). As well as establishing a

baseline for individual students' prior knowledge, this confirmed that we had recruited participants with comparable educational backgrounds.

*(2) Post-intervention academic performance (MCQ Exam 2)*

Students' marks significantly increased in both groups in the post-lecture exam (Fig. 2., Upper panel, *After Lecture: No disclosed SpLDs.* Mean mark = 63.4 +/- 17.9%, *Disclosed dyslexia.* Mean mark = 58.8 +/- 17.7%, 2-tailed T-test. MCQ1 vs MCQ2 marks. *No disclosed SpLDs* cohort *p*<0.0001; *Disclosed dyslexia* cohort *p*<0.0001) but there was no significant difference between the marks achieved by the two groups (2-tailed T-test, *p*=0.209), suggesting there were similar levels of engagement with the *'lecture – study – exam'* environment.

Subsequent analysis (Fig. 2., Lower panel), focussed on the difference in marks between the pre- and post-lecture exams (e.g. MCQ2 marks - MCQ1 marks). Participants were grouped into three categories according to whether they were given access to: (1) the lecture recording (Fig. 2, *Lecture Rec., n=40*) or (2), a section of textbook focussing on the lecture topic (Fig. 2, *Textbook, n=41*), and reported using these materials in the questionnaire. Participants reporting that they did not revise or use their allocated learning resource, were assigned to a third category (Fig. 2, *No Revision, n=9*).

**SUGGESTED FIG 2 HERE**

| Exam 1 (Before lecture) Mark (+/- sd) in % | | Exam 2 (After lecture + study) Mark (+/- sd) in % | | T-test *p =* |
|---|---|---|---|---|
| *Control* | *Discl. dyslexia* | *Control* | *Discl. dyslexia* | |
| 30.7 (+/- 16.1) | 33.4 (+/- 18.2) | | | .359 |
| | | 63.4 (+/- 17.9) | 58.8 (+/-17.7) | .209 |
| 30.7 (+/- 16.1) | | 63.4 (+/- 17.9) | | < .0001 |
| | 33.4 (+/- 18.2) | | 58.8 (+/-17.7) | < .0001 |

| | Control | | | Discl. Dyslexia | | |
|---|---|---|---|---|---|---|
| | NR | L. Rec | Txtbook | NR | L. Rec | Txtbook |
| **Difference in marks in % (+/- sd)** | 22.5 (13.3) | 35.4 (15.9) | 36.7 (21.7) | 15.0 (15.0) | 22.1 (18.4) | 32.4 (18.6) |
| **T-test** *p =* | < .002 | <.0001 | <.0001 | .158 | <.0001 | <.0001 |

**Fig. 2. Student academic performance. (Upper panel)** *Whole cohort marks pre- and post-intervention.* Student performance in multiple choice exams prior to, or after, the lecture and independent study. The performance of participants in the *Control / No disclosed SpLDs* or *Disclosing dyslexia* groups are presented separately. The table presents the average marks (+/- standard deviations) for multiple choice questions exams before (*Before lecture*) or after the lecture and independent study (*After lecture*). The significance of any differences between the average marks of these cohorts (2-tailed T-tests) are presented. **(Lower panel)** *Students' increase in marks between the pre- and post-lecture exams, differentiated by the learning materials used.* Any difference in marks between pre- and post-intervention exams were calculated, and grouped by whether they studied with a lecture recording (*Lecture Rec.)* or textbook (*Textbook*). Students that did not engage with a learning resource were analysed as a separate group (*No revision*). The table presents the difference in marks (+/- standard deviations) for these three groups of participants, and the significance of these changes (2-tailed T-tests). Cohort size = *Control / No disclosed SpLDs*, (n=50); *Disclosing dyslexia,* (n=42).

These data showed similar patterns of marks for both the *Control* group (e.g. *No disclosed SpLDs*) and those that disclosed dyslexia. In both groups, students that did not study with their learning resources showed an increase in performance above the pre-lecture exam (Fig. 2, *No revision*: *Control students*, Mean mark = 22.5 +/- 13.3%; *Disclosing dyslexia.* Mean mark = 15.0 +/- 15.0%), but this was significant only for participants with no disclosed SpLDs (2-tailed T-test, *Control group , p=.002*; *Disclosing dyslexia*, *p=.158*), presumably because of the small number of participants involved. In contrast, there were significant increases in marks when students studied with either the textbook (*Control* group. Mean mark = 36.7 +/- 21.7%; *Disclosed dyslexia*. Mean mark = 32.4 +/- 18.6%, 2-tailed T-test, *p< .0001*), or the lecture recording (*Control* group. Mean mark = 35.38 +/- 15.9%; *Disclosed dyslexia*. Mean mark = 22.1 +/- 18.4%, 2-tailed T-test, p<.0001). Importantly, we did not detect a significant difference in marks between students studying with either learning resource (2-tailed T-test. Textbook vs. lecture recording. *Control* group, *p=0.824*; *Disclosing dyslexia*, *p=.110*).

### 3.2 Questionnaire responses: Characterizing students' responses to lectures.

Many students that disclose dyslexia report difficulties with a number of academic skills, including taking notes in lectures (Mortimore & Crozier, 2006). As we hypothesised that lecture capture may be a means to compensate for this, we used a questionnaire to survey the extent of any note-taking difficulties students faced, and the factors that contributed to this (Fig. 3). This centred on the question *'I have problems taking notes in lectures'*, where responses were invited on a 5-point Likert scale. Interestingly, a substantial

proportion of participants in the *Control* group (*e.g. with no disclosed SpLDs*) agreed with the statement (Fig. 3: *Mostly Agree = 12%),* reinforcing that this is an area of difficulty for many students (Locke, 1977). However, this was markedly higher with those that disclosed dyslexia, where the majority disclosed note-taking difficulties (Fig. 3. *Definitely + Mostly Agree = 74%).* A subsequent question focussed on the underlying factors that contributed to these difficulties (Fig. 3. Right). All participants reported similar issues, though the response was markedly higher for those disclosing dyslexia, with a majority identifying the lecturer's speed of delivery (72%); writing and understanding at the same time (71%) or generating a complete set of notes (71%) as key issues. Two other factors – that students are often distracted in lectures (48%) or found their notes difficult to read (37%), were not identified as often.

**SUGGESTED FIG 3 HERE**

**Fig. 3. Assessing students' problems in note-taking in lectures**. (Left) Responses to the statement *'I have problems taking notes in lectures',* where participants responded on a 5-point Likert scale. (Right) Participants' identification of factors underlying their note-taking difficulties, where respondents indicated one or more issues as appropriate. Responses for participants in the *Control/No disclosed SpLDs* group, and those disclosing dyslexia are presented separately.

A second series of questions focussed on the strategies used to compensate for these difficulties (Fig. 4, Left). We found that about half of the control participants reported preparing for lectures by down-loading lecture handouts and making preparatory notes (*i.e. 43% 'Frequently' or 'Sometimes' make prior notes*), whereas this was substantially higher for those disclosing dyslexia (67%). In contrast, post-lecture activity was broadly comparable, with approximately half of the participants reporting using other sources to reinforce their notes after lectures (*Control* group: 52%; *Disclosing Dyslexia:* 46%, *Data not presented*), and with no marked differences between the learning materials used by either group of students (Fig. 4. Right). Most reported using online resources and/or textbooks, though those disclosing dyslexia were more likely to use a friend's notes to supplement their notes. Likewise, the use of digital voice recordings was largely specific to these students, presumably reflecting the encouragement of this approach by *Learning Support* teams.

**SUGGESTED FIG 4 HERE**

**Fig. 4. Student response(s) to their difficulties in taking notes in lectures. (Left)** Students were asked whether they downloaded lecture handouts and made notes prior to the lecture, or **(Right),** asked to indicate approaches and/or learning materials they used if they experienced difficulties taking lecture notes. One or more approach could be indicated as appropriate.

In summary, these data reinforced earlier studies (Fuller et al., 2010) that note-taking in lectures is a barrier for the majority of students that disclose dyslexia. However, our finding that ~10% of students that do not disclose a SpLD report similar problems, highlights how widespread this is in undergraduate cohorts.

### 3.3 Focus group discussions. Exploring students' views of lectures and independent study.

The finding that note-taking in lectures challenged many study participants, including a majority of those disclosing dyslexia, prompted us to explore this in more detail. We used focus groups to understand students' experience of lectures, concentrating on the nature and extent of any barriers they faced to learning; their responses to this (if any), and approaches to independent study, including their use of lecture recordings. Focus groups contained either (i), students with no disclosed SpLDs (*50 participants*), or (ii) those disclosing dyslexia (*42 participants*), to examine whether there were views specific to either group.

Thematic analysis found participants expressed a broad spectrum of views, many of which arose in several focus groups, suggesting we reached saturation. We identified four broad themes, including students' perceptions of: (i) the lecture format, (ii) taking notes in lectures, (iii) their approach(es) to independent study and (iv), the learning resources they used. Importantly, the majority of the topics raised and/or views expressed in many focus groups were indistinguishable, suggesting they were common to all students. However, in some areas the emphasis or discussion of practice diverged, suggesting there were sub-themes specific to students disclosing dyslexia. We present an overview of the themes/sub-themes identified (Table 1), and discuss these in detail below.

## The lecture format

*Identified in all groups*
- Negative views re. lectures
- Over-long (>1 hr) sessions
- Fast delivery
- Lack of guidance / learning outcomes
- Passive format / lack of interaction

*Control group-specific*
- Positive views re. lectures

*Discl. dyslexia group-specific*
- Problems w. short term memory
- Too embarrassed to ask questions
- Experience frequent distractions

## Taking notes in lectures

*Identified in all groups*
- Note taking is important
- Notes written on lecture handouts
- Aim to take comprehensive notes

*Disc. dyslexia group specific*
- Fast delivery is key problem.
- Difficulties in spelling technical terms
- Use emotive terms to describe poor notes / process of writing notes

## Independent Study

*Identified in all groups*
- Aim to consolidate notes and understanding.
- Frequent use of on-line resources
- Impact of time constraints and/or fatigue

*Disc. dyslexia group specific*
- Need (i) quiet study environment, and (ii) ability to take breaks.
- Need to 'rewrite' notes to address omissions

## Learning materials

*Identified in all groups*
- Textbooks valued as authoritative sources, but difficult to identify specific/relevant information.
- Online videos perceived as engaging, but concerns about relevance
- Lecture recording valued as 'insurance.'
- Used for note consolidation / revision
- Perceived as engaging
- Mixed response on whether recording impacts on lecture attendance

*Disc. dyslexia group specific*
- Textbook layout perceived as 'text heavy' and barrier to learning.
- Lecture capture valued for flexibility in (i) pace and/or (ii) accommodating personal approaches to study.
- Lecture capture allows students to focus on understanding rather than note taking in lectures
- Routine recording may encourage some students to miss lectures

**Table 1. Summary of themes and sub themes identified in focus groups.** The sub themes identified in all groups (left), and those associated with either the '*Control'* or '*Disclosing dyslexia'* groups are indicated.

**(1)** *Theme 1: Learning from lectures: the lecture format*

Initial discussion established that all respondents participated in lectures but there was variability in how these were used on individual programmes (*e.g. cohort size, level of interaction etc*.). Despite this, views were consistent across the cohort, with a small minority (all participants disclosing no SpLDs) expressing positive views about lectures, whereas the overwhelming majority of participants focussed on negative aspects. These centred on the issues of high contact hour programmes, sub-optimal timetabling (i.e. 'back-to-back' lectures) or on poor lecturer practice, rather than problems with the lecture format *per se*. Criticism of lecturers often centred on their speed of delivery, lecture structure and the readability of slides. For example, several students that disclosed dyslexia commented on slides being 'too busy' or hard to read due to the choice of colours, whereas both groups mentioned problems with diagrams with no accompanying written information, or a lack of learning outcomes / summaries in lectures. Interestingly, whilst many students commented on the lack of student interaction in lectures, this was often perceived as inherent to the format. Some participants suggested that students were partially responsible for this, as they failed to grasp opportunities for interaction due to negative peer pressure and/or embarrassment. This issue - of being too embarrassed to ask questions – was raised more frequently by students disclosing dyslexia.

*'If you have to ask questions during the lecture you can feel like you're putting everyone out and distracting people, which can stop you from asking.' (Participant with no disclosed SpLDs)*

*'If you want to ask a question, it's really intimidating in a hall of 100 plus people. The lecturer has to back-track on what they've said, and you can hear people huffing and puffing, and it's really embarrassing. So you don't ask, and you get lost. So everything that comes after that is lost.' (Participant disclosing dyslexia)*

*'The thing is with big lectures – no-one participates because it is too difficult.' (Participant disclosing dyslexia)*

Likewise, whilst many students commented on poor concentration or being easily distracted, these difficulties were raised more frequently by those disclosing dyslexia, together with problems retaining information in short-term working memory.

*'After about 40 minutes of a lecture, I zone out completely and then I come back in the last five minutes in the summary and I'm like 'Oh - what happened?' (Participant with no disclosed SpLDs)*

*'I hate lectures. I can't concentrate and I get distracted by everything else going on rather than by what they are saying' (Participant disclosing dyslexia)*

*'I find I basically forget. I can understand everything during the lecture, but then I come out and think I don't know what I learned' (Participant disclosing dyslexia*)

This suggested that the lecture format presents a number of challenges. Consistent with this, several participants reported using compensatory strategies, including reviewing learning materials (e.g. lecture slide handouts, etc.) prior to the session. Interestingly, this was only mentioned by students disclosing dyslexia, suggesting this was an important part of their study routine.

### Theme 2: Learning from lectures: taking notes

Student comments suggested that taking notes was a universal practice, typically directly onto the 'lecture handouts' (e.g. printed copies of the lecture slides). For many students, generating personal lecture notes was a key aspect of lecture attendance, with many reporting trying to create a verbatim record of the points made by the lecturer. For some students, this seemed to reflect surface learning approaches, though this may be a response to a perceived lack of guidance on the depth of learning required.

*'We get examined basically on the slides, so it's not a vast amount. It's not about reading things – so I find it's getting everything down that's on the slides' (Participant disclosing dyslexia*)

*'It can be hard to know how much to look at. It says you should read around the subject, but there are not clear enough guidelines' (Participant with no disclosed SpLDs*)

This suggested that prioritizing and/or summarising during note-taking was not widely practised, and may partially explain why speed of delivery was perceived as a major barrier to note-taking in lectures. This was raised more frequently by those disclosing dyslexia, suggesting it is a particular barrier, alongside working memory problems, and the difficulties of spelling unfamiliar technical terms*.

*'I struggle with the speed of the lecture is talking, and whilst you're trying to keep up you're missing the next bit' (Participant with no disclosed SpLDs*)

*'I sometimes feel that parts of my notes are missing because the whole thing goes so fast I can't keep up' (Participant with no disclosed SpLDs*)

*'If it isn't written on the slide or something, and is difficult to spell, you're so busy working out how to write it down, you've forgotten or missed what the lecturer was saying' (Participant disclosing dyslexia*)

*'I don't always understand it whilst I am writing it down. Then you get half way through writing it down and have forgotten what the rest of it is. Someone may be starting to talk about something else and you can't even remember what was said before' (Participant disclosing dyslexia)*

These difficulties appeared to have differential outcomes for the two groups. Whilst many students were dissatisfied with the quality of their lecture notes, the language used by those disclosing dyslexia to describe their notes (*e.g. 'chaotic', 'messy', 'scribble', 'confusing', 'nonsense', 'muddle'*) and the emotional terms many used to describe the process of writing them (*e.g. 'traumatic', 'stressed', 'panicking', 'battling'*) strongly suggested that the traditional lecture format placed these students at a disadvantage.

*'You are battling to listen to the lecture, and read what is on the slide, and make additional notes' (Participant disclosing dyslexia)*

*'When you get out of a lecture, it's like a sigh of relief, you just want to put your notes in the bin because it's so traumatic – especially when you have to write everything down' (Participant disclosing dyslexia)*

**Theme 3: Post-lecture independent study.**

Independent study represents a substantive proportion of undergraduate programmes and is when students build on what they have learnt in lectures. All participants confirmed that they engaged in independent study, that a major aim was to consolidate their lecture notes and that the bulk of this took place at home. However, comments on the nature of the study environment (e.g. quiet, distraction-free) or their study routine (e.g. in 'blocks', with pauses for breaks) were restricted to those disclosing dyslexia, suggesting that the concentration difficulties many of these students encounter in lectures also affect their independent study. Several participants also mentioned how fatigue could prevent further study, suggesting that programmes place substantial demands on students with SpLDs.

*'I think if you have time when you get home to go over it that day it can help, whereas sometimes you get busy and don't, and you forget. It's hard to do it every night especially if you're at uni. 9-5 and you've had six lectures that day' (Participant with no disclosed SpLDs)*

*'I tend to get up early in the morning because I can't work in the evenings – I can't focus. If you have had a day of uni, and I'm commuting as well, when I get in, I'm shattered and just want to go to bed. So some days I go to bed at 8.30' (Participant disclosing dyslexia)*

*'After a 5 hour day on a Monday I really don't feel like sitting there, making notes and looking at lecture notes but I can stick the recording on and I'll still be revising and listening to it' (Participant disclosing dyslexia)*

Students described two elements of independent study: an immediate 'consolidation phase', where queries in the lecture notes were resolved, and a later 'revision phase' prior to exams. For many students, the initial phase focussed on resolving minor omissions or straightforward queries (e.g. filling in 'gaps', defining technical terms), typically using online sources (e.g. Google, Wikipedia), whereas more conceptually demanding issues were resolved with different resources (e.g. online videos, textbooks, Facebook fora.)

*'I usually use my lecture notes if they are good enough and I can read them and I've got the majority of the points. I'll look at textbooks or look online to fill in the gaps' (Participant disclosing dyslexia)*

Several students that disclosed dyslexia described 'rewriting' their notes, reinforcing comments that they were inadequate. For some *'writing it up in neat,'* was a means of learning the material, but this extensive rewriting activity may partially explain why many students cited time constraints as a barrier to independent study.

*'I'm dyslexic, I'm not stupid – it's just that we don't have enough time. Like I've got processing problems too – everything takes me twice as long, so if I had that time I'd be getting top marks' (Participant disclosing dyslexia)*

*'I find that being dyslexic is a huge disadvantage. (…) It's not necessarily that information is difficult to understand, it's just there's so much of it. We normally have 8 (x) hour lectures a day - it's a huge volume to get through' (Participant disclosing dyslexia)*

### Theme 4: Supporting independent study: students' use of learning materials

Students reported using a range of materials to support their learning (e.g. textbooks, journal articles, online videos), depending on their individual preferences and study aims. As this study evaluated the role of supplementary lecture recordings, we focussed on comparing students' use of these and other resources.

*(i) Textbooks*

Recommended textbooks remain a key element of independent study in the majority of UG programmes and many students recognised their value as a reliable, systematic source of information. However, negative comments on their use, or that they were *a 'last resort'* were common. This appeared to reflect practical considerations – textbooks were perceived to contain too much information, and take too long to resolve specific queries, particularly when compared with online search engines. Several comments focussed on their 'text-heavy' format, though this was raised more frequently by students disclosing dyslexia. Likewise, comments that textbooks took too long to read, or were not useful, were restricted to these students, suggesting that this format presents particular problems for these learners.

*'It was black and white, and too much words, so I found it had more detail than I needed' (Participant disclosing no SpLDs*).

*'If I look at a book and it's just writing, writing, writing, I'm not going to even bother trying to read it. (…) That's my problem – I don't read' (Participant disclosing dyslexia*).

*(ii) Online videos (e.g. YouTube)*
In contrast to textbooks, online videos covering topics in the biological sciences (e.g. *YouTube, Khan Academy, Ted talks*) are a recent development in higher education. The majority of participants reported using videos, and found their multimedia format and short duration engaging. Students suggested that videos were useful for obtaining an overview of a topic, to get an alternative explanation of the material, or to understand visual concepts (e.g. manipulating limbs in physiotherapy).

*'Videos you get on YouTube can help to put the whole thing into context' (Participant disclosing no SpLDs* )

*'I use YouTube. I've used them for Psychology modules; Anatomy and Physiology. It's important to know if it's a reliable source - you get to know which ones are reliable and give you good information' (Participant disclosing dyslexia*)

However, one participant expressed concerns that video material may not be appropriate for their course, echoing similar comments that textbooks needed to be at an appropriate level to be relevant to their study.

*'I like the idea of videos, but I guess I'd be most concerned that I was learning what some American professor thinks is right for his module, rather than what you need to know for yours' (Participant disclosing no SpLDs*).

*(iii) Supplementary lecture recording*

We focussed on participants' perceptions and use of supplementary lecture recordings, however only a minority had experience of using lecture recordings outside of the study. Overall, students' responses to these materials were highly positive, often with a focus on their 'insurance' value for those who could not attend lectures, or as a way to revisit the lecture to address omissions or misunderstandings. This suggested that many participants used recordings for notes consolidation immediately after lectures, however comments that recordings could 'refresh your memory' were also consistent with their use in revision.

Students were positive in how recordings allowed flexibility in terms of study space (e.g. at home without distractions) and the pace at which the materials could be used. Many of those disclosing dyslexia commented on how they enabled them to take notes in their own time, incorporating breaks at will, though all students described ways of exploiting the technology to develop personal learning approaches.

*'In a lecture you're forced to go at the lecturer's pace, whereas when you watch a video, like you can pause, and have a break when you like' (Participant disclosing no SpLDs).*

*'I won't learn by hearing something once, so with the PowerPoint recording I can go over it again and again and again' (Participant disclosing no SpLDs).*

*'I find when I learn something new, I like to pause and stare at it for a while and take it in' (Participant disclosing no SpLDs)*

*'It's just easier really - I was able to pause it, rewind it, go over it again, to make sure that the notes I took were correct' (Participant disclosing dyslexia)*

*'I'd just listen to it, and every time they say something I don't understand I wrote it down and just keep pausing it and going back. There was one point where I had to listen 3 or 4 times just to understand what he was trying to say' (Participant disclosing dyslexia).*

Likewise, many students appreciated the ability to 'fast forward' and hone in on specific slides, consistent with a 'targeting' approach. This 'time efficiency' was important for many students, however, suggestions that learning from recordings was 'easier' suggested that some participants used recordings as a less demanding way to study. For some, this may be appropriate when fatigued; however, the effectiveness of

some approaches could be questioned, suggesting that guidance may be needed on how to use these resources.

*'It's much nicer to sit down and watch a video and know that you're absorbing something. You don't have to focus that hard, you can just refresh your mind' (Participant disclosing no SpLDs ).*

*'I listened to it whilst doing other things. So it was background noise coming in' (Participant disclosing dyslexia).*

Finally, the discussion focussed on the impact of routine lecture recording on student behaviour. Only one participant suggested there might be a negative impact, in contrast to several comments, primarily from those disclosing dyslexia, suggesting that it would allow them to focus on understanding rather than note-taking.

*'It makes me complacent in lectures if I can go home and listen to it. What's the point of coming in to University if you're going to go home and listen to the same thing?' (Participant disclosing no SpLDs).*

*'If you are in a lecture room, and think 'I don't get this', instead of panicking you can think 'Oh well – I'll watch it later' (Participant disclosing dyslexia).*

*'People were a lot more relaxed, about just sitting back and listening to the lecture and knowing that the information is somewhere else, and you can use the lecture recording to get your head around it' (Participant disclosing dyslexia).*

Views on whether lecture capture impacted on attendance appeared to be shaped by students' personal responses to these sessions. Many suggested there would be little impact because they valued the routine of attending sessions, or aspects of lectures that could not be captured on recordings (e.g. question and answers, non-verbal cues).

*'In a lecture you can put your hand up right away and the lecturer can give you the correct answer. If you're forced to use the internet it might not be correct or have a different depth of detail' (Participant disclosing no SpLDs).*

However, others disagreed, with mixed evidence from those with experience of lecture capture – some had witnessed reduced attendance, whereas others had not. Only three students disclosed that they had

previously chosen not to attend lectures due to the availability of recordings. Interestingly, all disclosed dyslexia, and either focussed on the flexibility the technology, or the time required to take notes from recordings.

*'I would use the recording and drop the lecture itself, and do some more revision with the time' (Participant disclosing no SpLDs).*

*'I can sit there when I'm ready to study, with food on the couch, and can pause it – rather than attend a lecture' (Participant disclosing dyslexia).*

*'I thought my time was more beneficial sitting doing some reading during the hour of the lecture. It would take me about two hours to go through it after it was posted, so it was like 'What is the point of being there for a third hour when I could use my time more effectively?' (Participant disclosing dyslexia).*

## 4. Discussion

### 4.1 General discussion

Supplementary lecture recording is now commonly available in higher education; widely used by students (Soong et al., 2006), and can increase their academic performance (Brooks et al., 2014). Here, we explored whether this approach can support students who encounter academic difficulties, and can have a wider role to play in developing more inclusive curricula for students disclosing Specific Learning Difficulties. We found that lecture recordings support the academic performance of all students, including those disclosing dyslexia, and are particularly valued by those who have difficulties taking notes in lectures. As such, this study provides the first evidence that lecture capture can support the attainment of students disclosing SpLDs, and gives insight into how these resources support students' learning.

### 4.2 Exploring students' problems with learning from lectures

Lectures play a central role in many STEM programmes, despite gaining a reputation for being (at worst) an unengaging format associated with 'passive learning'. Learning in these environments also requires note-taking, a high level skill that challenges a significant proportion of students (Piolat et al., 2005), including many that disclose dyslexia (Hughes & Suritsky, 1994). Our findings that ~10% of participants disclosing no SpLDs, and ~75% of those disclosing dyslexia, reported note-taking difficulties emphasises the extent of these issues in undergraduate cohorts. Likewise, our finding that a higher proportion of those disclosing dyslexia develop compensatory approaches (e.g. accessing materials prior to lectures), presumably reflects

the greater difficulties that these students experience. These data were reinforced by our focus group discussions, where many students described experiencing difficulties with note-taking, but these were more pronounced for those disclosing dyslexia, consistent with a previous qualitative study (MacCullagh et al., 2016). Our data suggests that compensating for these difficulties in high contact STEMM programmes is a substantial *additional* workload for these students, and this may be a significant barrier to their academic performance.

### 4.3 Student responses to lecture recordings

This study indicates that independent study with supplementary lecture recordings can support significant increases in academic performance, and this is comparable to study with traditional learning materials (e.g. textbooks, Fig. 2). This is the first evidence that recorded materials can support attainment in those disclosing dyslexia, though how they do this is less clear. Focus groups with students disclosing dyslexia indicated (i) that recordings present fewer difficulties than text based materials, suggesting they are more effective way to support learning, but that (ii) students' use of recordings is complex, with some using these materials to resolve misunderstandings and/or enable note-taking, whereas others focus on using them for revision. We found that the innate flexibility of the technology was important, either by enabling a range of learning approaches (i.e. including 'overlearning') and/or the efficient targeting of specific parts of the lecture. This focus on addressing misunderstandings and/or revision is consistent with previous studies (Bassili & Joordens, 2008; MacCullagh et al., 2016; Hall & Ivaldi, 2017), and the pattern of download activity typically seen with lecture recordings (e.g. Leadbeater et al., 2013; Eliot & Neal, 2016), with an initial 'peak' associated with note consolidation immediately after lectures, and a second 'peak' associated with revision prior to the exams. These different approaches appear to have differential impacts on attainment – only students that use recordings *regularly* appear to gain academic benefit (Brooks et al., 2014), suggesting that the value students place on revision with recordings (Evans, 2008), particularly in a 'last minute' manner prior to the exams may be misguided.

### 4.4 Study limitations and areas that warrant further study

The study has a number of limitations that may impact on the outcomes or whether they can be generalised. Many reflect our use of an empirical approach, where it is unclear whether (i) the participants we recruited, or (ii) the study design / learning environment used is a good model of the broader HE experience.  Both issues are pertinent and worth discussing: (i) *The study participants* are highly diverse, and were recruited from a broad range of biological science based programmes in several institutions, and from all years of undergraduate study. This allowed us to recruit a large cohort of students disclosing dyslexia, but also increased the range of participants' background knowledge, interests, aptitude and study experience. Our

use of a pre-lecture test to assess and compensate for this diversity can only partially address this issue. Likewise, recruiting participants from similar programmes into *'Control'* or '*Disclosing Dyslexia'* groups will only partially compensate for this diversity. A related limitation centres on whether the students recruited (despite a reasonably generous payment) are typical of the wider cohort, or whether there has been self-selection by students (e.g. with positive views of lecture capture). The observation that our recruits were overwhelmingly and disproportionately female, suggest that this effect may be relevant to our study, though its impact is unclear.

Similarly, whether (ii) **The study design** replicates the HE experience is also difficult to assess. The *lecture – study - exam* design was familiar to the participants, and our data show that learning took place, but it is inevitable that students will behave differently in an educational study (*e.g. take less comprehensive notes and/or devote less time to revision*) than on their programme when the stakes are much higher. This lack of insight into participant behaviour highlights several areas that were not investigated, but could give context to the study findings. For example, the study establishes that students performed equally when given access to textbooks or recordings (i.e. the outcomes are the same), but we do not understand the process that enabled this. Students disclosing dyslexia may have devoted more effort and time when using textbooks to achieve the same outcome. Likewise, our understanding of participant's note-taking in the lecture (*e.g. Are they comprehensive / accurate?),* and engagement with learning materials (*e.g. Did participants take notes and/or just review the material?)* are limited, and warrant further investigation to understand how lecture recordings enhance learning. Finally, given the study's focus on the biological sciences, it is unclear whether the findings apply to other disciplines. Given that students particularly value lecture recordings in programmes that tend to focus on facts and lecture-based delivery (Danielson et al., 2014), it would be interesting to build on this study in a wider range of disciplines

Finally, the study also raises a number of broader areas that need further research:

(i) *Further evaluation with different students / enhanced recordings*
This study focusses on a subset of students that disclose SpLDs, but there is some evidence that recordings can support students with difficulties in transcribing academic English (e.g. some with Non-English Speaking Backgrounds; Pearce & Scutter, 2010), or accessing lectures (e.g. students with physical disabilities, demanding domestic and/or work commitments etc.). These areas could be evaluated in more detail. Likewise, enhancing recordings with lecture transcripts and/or captioning, may accommodate the needs of students with a wide range of learning difficulties, but this remains largely unstudied. This suggests that the inclusive potential of lecture capture is yet to be fully explored.

(ii) *Develop academic training on use of lecture recordings*

Further studies are needed on how to optimise the integration of lecture capture into undergraduate programmes. Our focus groups identified surface learning attitudes (Dolnicar, 2005) and/or ineffective use of recordings amongst our study participants (James et al., 2017). Training on the appropriate use(s) of these resources (e.g. Boyle & Rivera, 2012) may be a way to enhance students' learning and attainment.

## 5.0 Conclusions: Supplementary lecture recording is an inclusive approach

This study presents data indicating that supplementary lecture recording can be an effective support mechanism for students who experience difficulties in lectures, and can contribute to creating a 'level playing field' in these sessions. This is consistent with the difficulties that many students disclosing dyslexia encounter with this teaching format (Hughes & Suritsky, 1994), and their increased use of lecture recordings in UG programmes (Leadbeater et al., 2013).

Students identified a number of benefits to recordings. Many found the format engaging (particularly in comparison with textbooks), but the flexibility of the technology is also important (e.g. enabling scanning to specific slides, pausing, repeating sections etc., Bassili & Joordens, 2008), as this allows personalised and/or time efficient ways to study. This was a key issue for many disclosing dyslexia, where the condition encourages them to adopt distinct approaches to learning, and where note-taking difficulties often drive them to engage in extensive note-rewriting and/or consolidation activity after lectures.

In summary, we provide evidence that supplementary lecture capture can support the learning of a substantial proportion of students disclosing learning difficulties, but given the diversity of UG cohorts, no single intervention is likely to be fully effective. A combination of supportive technologies and a wider range of curricular approaches / learning environments will need to be developed to create a genuinely inclusive curriculum.

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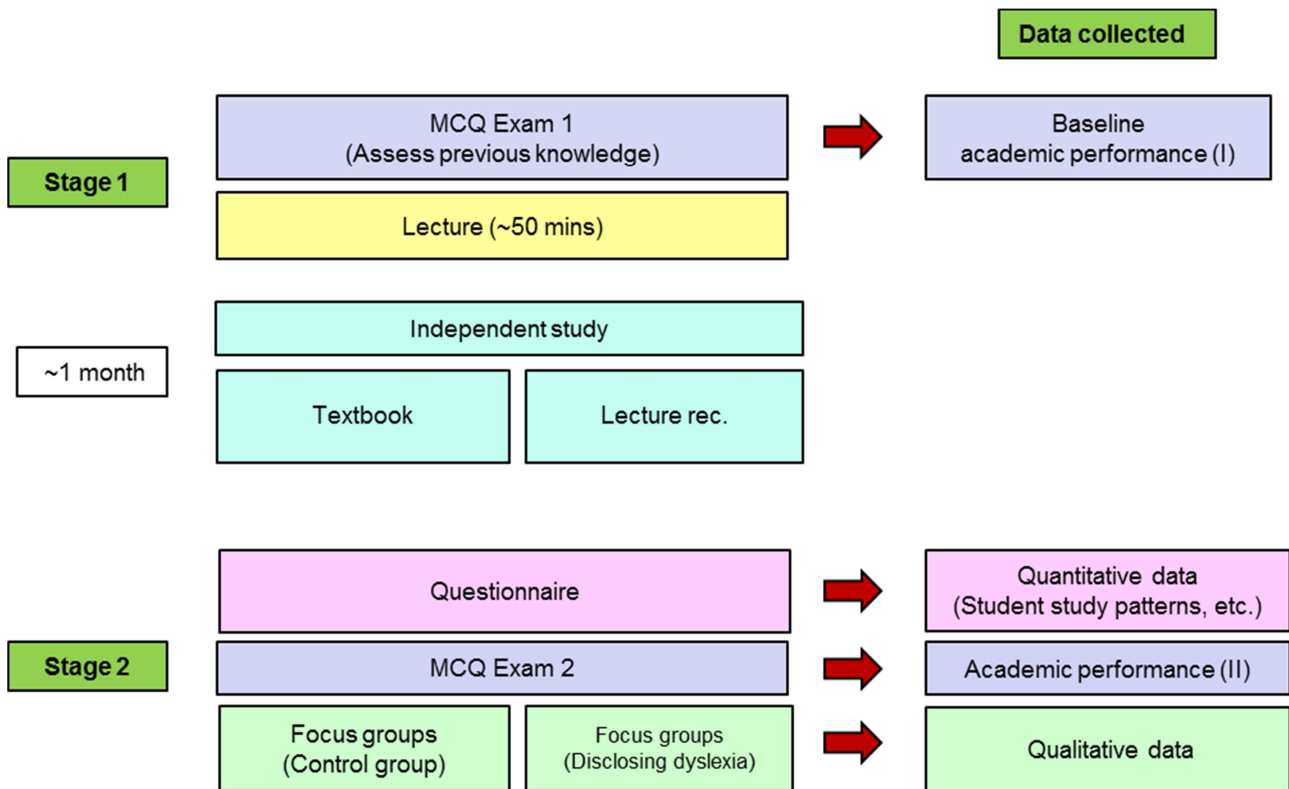
**Acknowledgements**

**Fig. 1. Study design, including the points at which data were collected.** Participants were recruited at *Stage 1*, where a short multiple choice question-based exam was administered (*MCQ Exam 1*), prior to the lecture. Participants were randomly assigned to one of two groups who were asked to study with either a textbook or lecture recording, prior to *Stage 2,* approximately four weeks later, where they were re-examined on the lecture topic (*MCQ Exam 2*). During this session, participants were asked to complete a questionnaire about their study methods, and participate in focus groups.
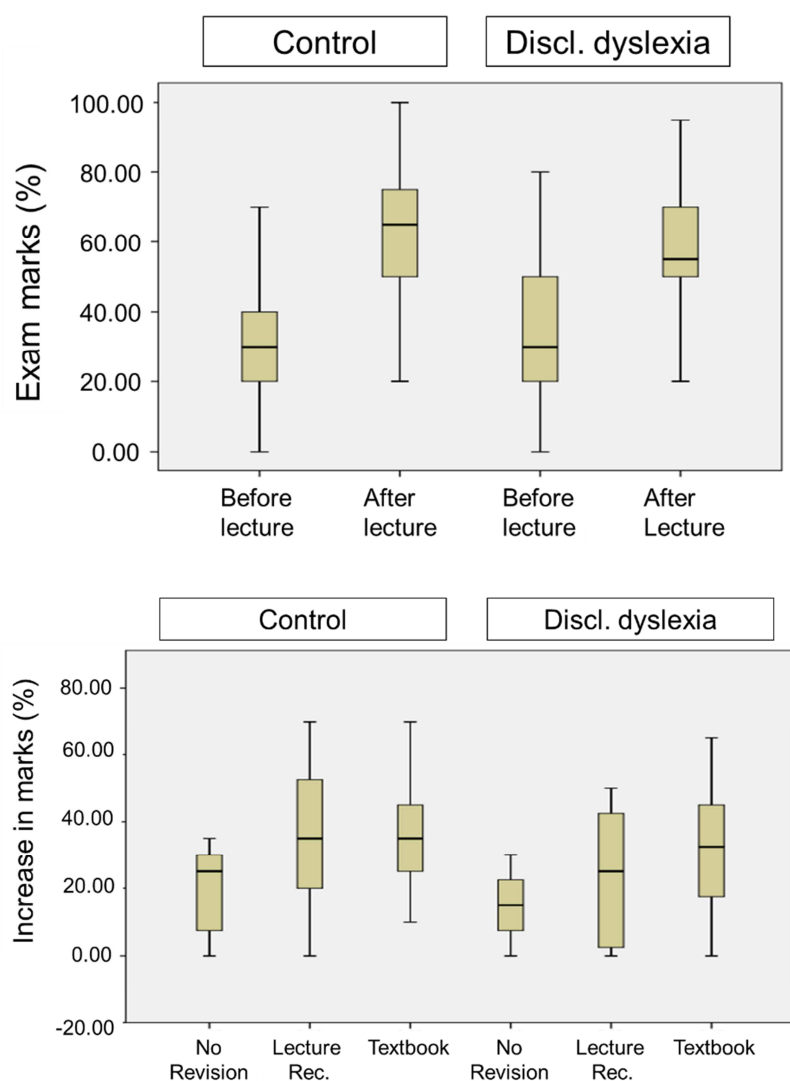
**Fig. 2. Student academic performance. (Upper panel)** *Whole cohort marks pre- and post-intervention.* Student performance in multiple choice exams prior to, or after, the lecture and independent study. The performance of participants in the *Control / No disclosed SpLDs* or *Disclosing dyslexia* groups are presented separately. **(Lower panel)** *Students increase in exam performance differentiated by the learning materials used.* Any difference in marks between pre- and post-intervention exams were calculated, and grouped by whether they studied with a lecture recording (*Lecture Rec.*) or textbook (*Textbook*). Students that did not engage with a learning resource were analysed as a separate group (*No revision*). Overall cohort = *Control / No disclosed SpLDs*, n=50; *Disclosing dyslexia*, n=42.
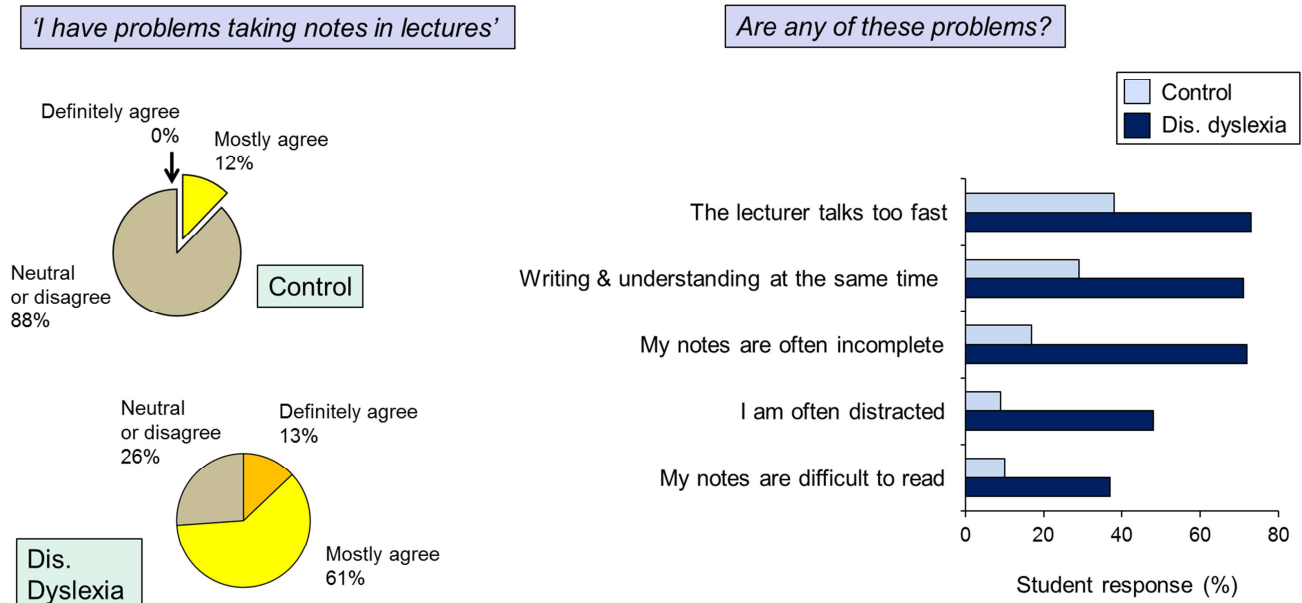
**Fig. 3. Assessing students' problems in note-taking in lectures**. (Left) Responses to the statement *'I have problems taking notes in lectures',* where participants responded on a 5-point Likert scale. (Right) Participants' identification of factors underlying their note-taking difficulties, where respondents indicated one or more issues as appropriate. Responses for participants in the *Control/No disclosed SpLDs* group, and those disclosing dyslexia are presented separately.
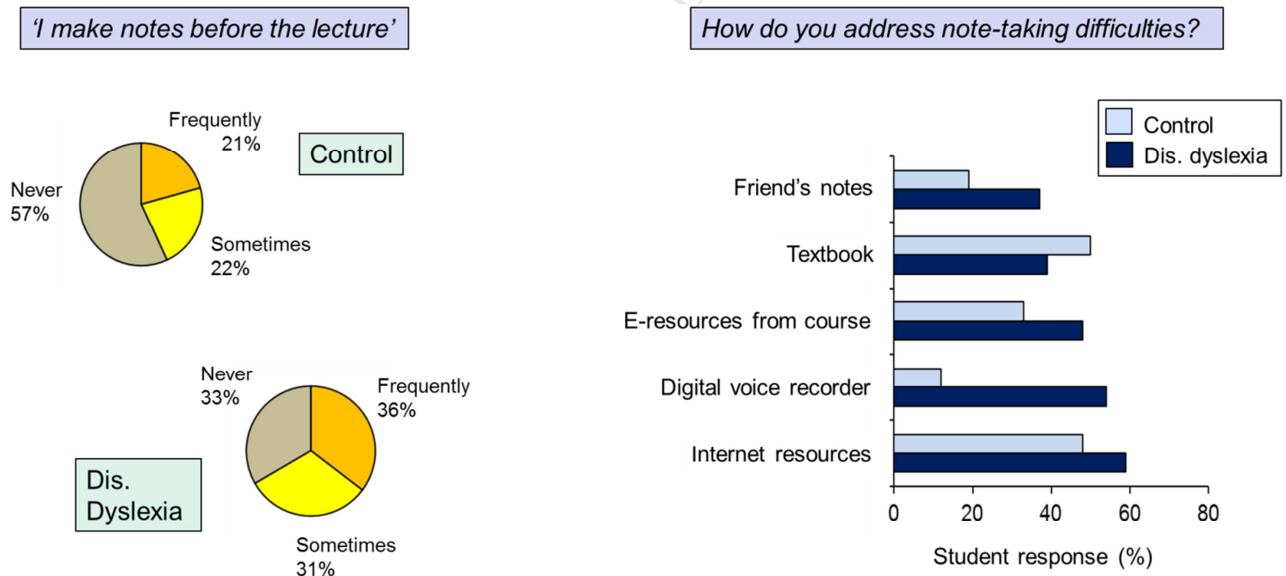


**Fig. 4. Student response(s) to the difficulties of taking notes in lectures. (Left)** Students were asked whether they downloaded lecture handouts and made notes prior to the lecture, or **(Right),** asked to indicate approaches and/or learning materials they used if they experienced difficulties taking lecture notes. One or more approach could be indicated as appropriate.

Highlights

- We evaluate whether supplementary lecture recordings can support the learning of students disclosing dyslexia.
- We use a mixed methods approach to understand the barriers presented by lectures, and the ways students use lecture recordings.
- We show lecture recordings can support significant increases in academic performance in students disclosing dyslexia.
- We conclude that supplementary lecture recording can contribute to inclusive curricula