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**Relationship between lecture capture usage and examination performance of undergraduate bioscience students**

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**Running head:** Lecture capture and examination performance

## Abstract

Lecture capture recordings of audio together with video images of slides are widely used in higher education institutions. Lecture capture is highly valued by students. However, the effect of lecture capture usage on student learning is not well understood and is the subject of some controversy. The objective of this study was to investigate the relationship between lecture capture usage and examination performance of undergraduate students in order to test the hypothesis that students who use lecture capture recordings more extensively perform better in their end of module examinations. The hypothesis was tested using data from students enrolled on a range of second year (stage 2) and third year (stage 3) bioscience modules and fitted to linear mixed models considering potential confounding from gender, nationality and disability status. The results showed that there was no relationship between lecture capture usage and examination performance in this cohort of students. However, a recorded disability and non-UK nationality were both moderately predictive of poorer performance. These findings suggest that lecture capture has neither a positive nor a negative effect on academic performance. This raises a question over the value of providing lecture capture at higher education institutions.



## Keywords

Examination performance / Higher education / Learning / Lecture capture


## Introduction

Lecture capture recordings of audio together with video images of slides are widely used in higher education institutions, although their usage and effect on student learning are not well understood. Indeed, there is a concern among some that lecture capture recordings may negatively impact on student attendance and thus may disadvantage student learning. Lack of understanding of the relationship between usage of lecture capture and student performance, in addition to decreasing student turnout at lectures, may in part explain a general resistance to lecture capture technology among academic staff (Bond &

Grussendorf, 2013; Brady, Wong, & Newton, 2013; Marchand, Pearson, & Albon, 2014). Nonetheless, lecture recordings are popular among students and are becoming an important resource in UK higher education and their provision is often expected by students (O'Callaghan, Neumann, Jones, & Creed, 2015). The relationship between student absence from lectures and usage of lecture capture appears to be complex and highly variable; a large proportion of students who miss lectures do not catch up by accessing captured lectures (Brady et al., 2013). Lecture capture usage appears to vary with time, such that there are clear spikes in the number of viewings coinciding with the days preceding summative assessments (Elliott & Neal, 2016), suggesting that the assessment is a more important predictor of usage than absence (Brady et al., 2013).

Lecture capture may benefit student achievement by enabling students to focus on challenging concepts and revisit critical information. On the other hand, availability of recordings may weaken skills in note-taking and live information processing. The literature exploring the relationship between lecture capture usage and examination performance is fairly limited, with some studies claiming benefits and others suggesting no effect or a negative relationship (Karnad, 2013; Kinash, Knight, & McLean, 2015; O'Callaghan et al., 2015). A study in 2013 found that lecture capture usage among medical science students had no impact on examination performance compared to those who did not use the system (Leadbeater, Shuttleworth, Couperthwaite, & Nightingale, 2013). However, this study did not investigate frequency or duration of usage. In another study of undergraduate biological sciences students, availability of lecture capture recordings resulted in a 5 % increase in average exam grades (Wiese & Newton, 2013). However, this was in comparison to historical controls from a different student cohort. In addition, the analysis did not control for potential confounding variables, e.g. gender, disability status or nationality. A similar study of computer science students found the opposite: academic performance of students who had access to lecture capture recordings was significantly worse than for those who studied prior to the introduction of recorded lectures (Settle, Dettori, & Davidson, 2011). A separate case-control study of nursing students taking an anatomy and physiology course found that the group of students provided access to lecture capture performed marginally but significantly worse than those who attended lectures without access to recordings (Johnston, Massa, & Burne, 2013). However, the student cohorts were from different campuses. A different study found that lecture capture usage nullified the negative effect of absence from classes on academic performance (Traphagan, Kucsera, & Kishi, 2010). On the other hand, a large 3-year controlled longitudinal study including data from 98 academic courses found that provision of lecture capture had no significant impact on examination scores (Brotherton & Abowd, 2004). Interestingly, a different study found that higher achieving health sciences students viewed lecture capture recordings significantly less frequently than lower achieving students (Owston, Lupshenyuk, & Wideman, 2011).

In general, lecture capture is highly valued by students (O'Callaghan et al., 2015). Questionnaire data show that students find the facility useful for revision and to aid understanding of challenging concepts (Elliott & Neal, 2016; McCunn & Newton, 2015; Settle et al., 2011; Toppin, 2011). Based on this evidence, several reviews thus propose that lecture capture is a useful tool to aid independent study (Elliott & Neal, 2016; Karnad, 2013; Kinash et al., 2015). However, as indicated above, the relationship between lecture capture usage and academic performance remains controversial, and more careful analysis of available evidence, considering potential confounders, is required.

The objective of this study was to investigate the relationship between lecture capture usage and examination performance of undergraduate students in order to test the hypothesis that those who use lecture capture recordings more extensively perform better in their examinations. The hypothesis was tested using data from students enrolled on a range of second year (stage 2) and third year (stage 3) bioscience modules (n = 4 from each stage). The modules are one term in length and form part of the 3-year BSc honours degree programmes offered in the Department of Biology at the University of York. The modules were taught in 2017-18. Gender, nationality and disability status were considered as potential confounders based on prior evidence (Barrow, Reilly, & Woodfield, 2009; Prevatt, Welles, Li, & Proctor, 2010).

## Materials and Methods

### *Data collection*

The study was approved by the Department of Biology Ethics Committee at the University of York. Lecture capture usage data were downloaded from the Panopto lecture recording system for eight modules taught as part of the 3-year bioscience BSc honours programmes in the Department of Biology at the University of York in 2017-18. These modules were selected for analysis because they had relatively large cohort sizes compared to others in the programme. Four stage 2 modules were included: Immunology (n = 196), Molecular biotechnology (n = 106), Species-environment interactions (n = 61), and Mechanisms of genetic change (n = 91). Four stage 3 modules were also included: Cancer and the cell cycle (n = 74), Cell and tissue engineering (n = 95), Learning and memory (n = 85), Bacterial pathogenesis (n = 65). The Panopto system provided two measurements of lecture capture recording usage for each student on each module: the total number of views, and the total number of minutes delivered. The data were downloaded after the final assessment period and so covered the full 10 weeks of the module as well as the 5-week revision period prior to the examination.

Data on students and examination results were obtained from the Department of Biology student database. The student-related data were: student identifier, IT username, gender, nationality, and disability status. Degree route and module examination marks came from a second database.

The data from Panopto, student-related information and examination marks were combined into a single spreadsheet. IT username was used to cross-refer the Panopto data to the student-related data and student identifier was used to cross-refer the student-related data to examination marks. Disability data were used to subdivide students into two classes: disability or no recorded disability. Recoded disability included any type of disability declared by the student (e.g. mental, physical, intellectual, etc.). Students were subdivided by nationality into two groups: UK national (British) and non-UK (not British). Data on which students were native English speakers were not available. Once all necessary data had been combined, student-identifying information (IT services username and student identifier) was deleted. All data were therefore fully anonymised for the subsequent analysis.

***Data analysis***

Statistical analysis was performed using IBM SPSS Statistics version 25.0. Graphs were produced using GraphPad Prism version 7.0d. The dependent variable, examination score, expressed as a percentage, was first transformed to a fraction and then logit transformed to achieve a near-normal distribution (Baum, 2008). Normal distribution was independently evaluated using D'Agostino-Pearson omnibus normality test as well as by comparative visual inspection of histograms, QQ and box plots of raw and transformed data.

The relationship between lecture capture usage parameters, potential confounders (gender, nationality status, disability status) and examination performance was evaluated using a linear mixed model within the MIXED package of SPSS. Initially, the overall model considered data from both stages combined. Individual students were considered as subjects and logit-transformed examination marks as the dependent variable. Module was considered as a random factor, and gender, nationality, disability, total minutes delivered, number of views and intercept as fixed factors. For simplicity, and to aid interpretation, no 2-way or 3-way interactions were considered in the model.

Based on the Aikake Information Criterion (AIC), the model was iteratively refined, removing the least significant factor on each iteration, until the most parsimonious model was achieved. Next, two further models were produced, exactly as above, considering data from each stage separately (one model for stage 2 data and one model for stage 3 data). Parameter outputs from each model were considered significant at $P < 0.05$. The intraclass correlation (ICC) was calculated as the ratio of the between-module variance to the total variance (residual + intercept). Finally, each model was evaluated based on visual inspection of plots of residuals versus fitted values.

***Summary of data***

The dataset included information from 763 students of which 454 (59.5 %) were in stage 2 and 309 (40.4 %) were in stage 3. All had a recorded examination score (from 0-100 %) on at least one of the included modules. There were 496 female students (65.0 %) and 267 male students (35.0 %). There were 156 students with a recorded disability (20.4 %) and 607 students with no recorded disability (79.6 %). There were 684 students who were UK nationals (89.6 %) and 79 students who were non-UK nationals (10.4 %). Within the cohort, 718 students had accessed the lecture capture system, defined by total number of views ≥ 1 (94.1 %), and 45 students had not used the system (5.9 %). Descriptive statistics of examination marks at the level of student characteristics and module are in Table 1. The examination marks failed the D'Agostino-Pearson omnibus normality test ($P < 0.001$) and this was confirmed by visual inspection of the histogram, QQ and box plots of the data (Figure 1A-C). Marks were therefore converted to a fraction and logit transformed (Baum, 2008). Although the transformed data still failed the D'Agostino-Pearson omnibus normality test ($P < 0.001$), the skewness of the distribution was markedly improved (Figure 1D-F). The multivariate analysis was therefore performed on the transformed data.

## Results

***Relationship between lecture capture usage and exam performance across stages***

To investigate the relationship between lecture capture usage and exam performance, an overall linear mixed model was used, including data from stage 2 and 3. Two measurements of lecture capture usage were considered: total number of views and total number of minutes delivered. The full model included module as a random factor, and gender, nationality, disability, total minutes delivered, number of views and intercept as fixed factors. Gender was the least significant factor ($P = 0.948$) and so this was removed to refine the model (Table 2). The model was further refined by next removing total minutes delivered based on the rationale that not only was it the next least significant factor, but it was also conceivable to expect correlation between total minutes delivered and number of views ($P = 0.214$; Table 2). The most parsimonious model including lecture capture data thus contained module as a random factor, and number of views, nationality and disability as fixed factors (Table 2). This model revealed that number of views was not a significant predictor of examination performance ($P = 0.115$; Figure 2A). Similarly, the low intraclass correlation revealed that module was not predictive of examination performance (Table 2; Figure 2B). However, both nationality and disability status were predictive of examination performance. UK students performed significantly better than non-UK students ($P < 0.01$; Figure 2C). In addition, students with no recorded disability performed significantly better than students with a recorded disability ($P < 0.001$; Figure 2D).

***Relationship between lecture capture usage and exam performance within each stage***

In the second model, the relationship between lecture capture usage and exam performance was evaluated using a linear mixed model including data from stage 2 only. Following the most parsimonious model above, the second model included module as a random factor, and nationality, disability, number of views and intercept as fixed factors (Table 3). This model revealed, as with the first model, that number of views was not a significant predictor of examination performance ($P = 0.150$). Nationality was also not predictive of examination performance ($P = 0.098$). Similarly, the low intraclass correlation revealed that module was not predictive of examination performance. However, disability status was predictive of weaker examination performance ($P < 0.05$).

In the third model, the relationship between lecture capture usage and exam performance was evaluated using a linear mixed model including data from stage 3 only. Again, the model included module as a random factor, and nationality, disability, number of views and intercept as fixed factors (Table 3). This model revealed, as with the above models, that number of views delivered was not a significant predictor of examination performance ($P = 0.425$). Similarly, the low intraclass correlation revealed that module was not predictive of examination performance. However, UK students performed significantly better than non-UK students ($P < 0.05$) and students with no recorded disability performed significantly better than students with a recorded disability ($P < 0.01$; Figure 2D).

In conclusion, there is no relationship between lecture capture usage, measured by total number of views and total number of minutes delivered, and examination performance in this cohort of students. However, a recorded disability and non-UK nationality are both moderately predictive of poorer performance. Plotting the residuals vs. fitted values revealed random distributions without obvious outliers, suggesting that these models were appropriate fits to the data (Figure 3A-C).

**Discussion**

The main finding of this study was that there was no relationship between usage of lecture capture recordings and examination performance across eight bioscience modules taught at the University of York in 2017-18. This conclusion is based on analysis of two measurements of lecture capture usage: number of views of any lecture(s) on a module and the total number of minutes viewed. Consideration of data from stage 2 and 3 combined or in isolation gave the same result. Several other contributing factors were included in the modelling of these data. Examination performance was not significantly different across the 8 modules studied. In addition, examination performance was similar for male and female students. However, examination performance was dependent on nationality and disability status. Examination marks were slightly, but significantly higher for UK students than non-

UK students. Similarly, examination marks were slightly, but significantly higher for students with no declared disability than for those with a declared disability.

A strength of this study is the large sample size through inclusion of multiple large modules of students across two stages in several bioscience undergraduate programmes. Consideration of two measures of lecture capture usage at the level of individual students, collected accurately and automatically by the Panopto lecture capture system is an additional strength. Furthermore, inclusion of several confounders, which are potentially related to lecture capture usage and/or examination performance (Barrow et al., 2009; Prevatt et al., 2010), including gender, disability status and nationality status, into the linear mixed model provide further confidence in the conclusions given the heterogeneous nature of the population under study. There are, however, several weaknesses in the approach used in this study. First, the study is, by design, observational, and can therefore identify correlation but not causation. Second, although several potential confounders were considered, it is possible that additional unidentified factors in the population may also have contributed to academic performance, for example, prior achievement of the students under study (Barrow et al., 2009; Richardson, Abraham, & Bond, 2012). Thus, it is not clear whether lecture capture usage affects student performance or whether student performance/ability affects lecture capture usage. Third, subdivision of subjects into binary groups based on nationality and disability status may be an oversimplification of the true contribution of these factors to examination performance. For example, students with certain types of disability may rely on lecture capture to a greater extent than others, which may indirectly affect examination performance. Similarly, native language status may be a better predictor of lecture capture usage than nationality since English may be the first language for many non-UK students.

In comparison to other studies exploring the relationship between lecture capture usage and examination performance (Karnad, 2013; Kinash et al., 2015; Leadbeater et al., 2013;

O'Callaghan et al., 2015; Settle et al., 2011; Wiese & Newton, 2013), a strength of this study is the use of a multivariable linear mixed regression approach to include gender, nationality and disability as predictors in addition to lecture capture usage. However, a weakness is that this study did not consider absenteeism or prior achievement of students, which may both be predictive of lecture capture usage and/or examination performance (Owston et al., 2011; Traphagan et al., 2010). An alternative approach would be to undertake a multi-year longitudinal study including data from additional academic courses (Brotherton & Abowd, 2004). This study was observational, and the study population was uncontrolled. It would, of course, be unethical to undertake a randomised controlled interventional study in which a control arm contained students who were unable to access lecture capture recordings compared to a test arm containing students who were able to access such a resource. In addition, owing to changes in module structure and content in recent years, it was not feasible to compare performance of students on the same modules in previous years before lecture capture was introduced. However, an observational case-control design has been used previously to study relationship between access to lecture capture and academic performance, although a weakness was that the cohorts were from different campuses (Johnston et al., 2013).

There is considerable controversy among the various studies exploring the relationship between lecture capture and academic performance (Karnad, 2013; Kinash et al., 2015; O'Callaghan et al., 2015). The present study agrees with others that have shown no relationship between lecture capture usage and examination performance (Brotherton & Abowd, 2004; Leadbeater et al., 2013). However, it disagrees with studies showing a significantly positive (Traphagan et al., 2010; Wiese & Newton, 2013) and negative (Johnston et al., 2013; Settle et al., 2011; Williams, Birch, & Hancock, 2012) relationship. The reasons for these discrepancies are not clear. However, it is likely that the various weaknesses in the design of various studies discussed above are contributing factors, critically the predominantly observational and inadequately controlled nature of the studies.

Nevertheless, the facility of lecture capture is highly regarded by students (Elliott & Neal, 2016; O'Callaghan et al., 2015; Settle et al., 2011; Toppin, 2011) and is becoming ubiquitous at UK higher education institutions.

This study, whilst it does not resolve the controversy surrounding lecture capture usage in the literature, does have several important implications for teaching practice. First, the findings suggest that in this cohort of bioscience students, lecture capture has neither a strong positive nor a strong negative effect on academic performance, with the caveat that there may be unidentified small effects within subpopulations of students. The overall finding should allay any concerns that lecture capture disadvantages student learning among bioscience students. Second, the finding that students with a disability perform slightly, but significantly worse than students without a disability, and that non-UK students perform slightly, but significantly worse than UK students, is of interest. At the very least, this highlights that disabled and non-UK students are intrinsically disadvantaged and, although support is typically provided for these populations at higher education institutions, careful consideration of the level of this support would be prudent. For example, closed captions and transcripts, which were not provided with the lecture capture recordings on these modules, may be of benefit to this population. Finally, this study raises a question over the rationale behind providing lecture capture at higher education institutions given the lack of a positive correlation with academic performance. Even though students appreciate the provision (Elliott & Neal, 2016; O'Callaghan et al., 2015; Settle et al., 2011; Toppin, 2011), does lecture capture really represent value for money to institutions and departments paying for the service?

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**Declaration of interest statement**

There is no conflict of interest.

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**Table 1.** Description of marks at the level of student and module

| Variable | n | Mean exam score | SEM |
|---|---|---|---|
| ***Student characteristics*** | | | |
| Gender – male | 267 | 60.9 | 0.9 |
| Gender – female | 496 | 60.7 | 0.6 |
| Nationality – UK | 684 | 61.2 | 0.5 |
| Nationality – non-UK | 79 | 57.2 | 1.8 |
| Disability – no | 607 | 61.7 | 0.6 |
| Disability - yes | 156 | 57.2 | 1.2 |
| ***Module*** | | | |
| 2I Immunology | 196 | 57.6 | 1.2 |
| 8I Molecular biotechnology | 106 | 65.7 | 0.9 |
| 22I Species-environment interactions | 61 | 63.9 | 1.0 |
| 33I Mechanisms of genetic change | 91 | 54.1 | 1.9 |
| 8H Cancer and the cell cycle | 74 | 62.6 | 1.3 |
| 9H Cell and tissue engineering | 85 | 64.5 | 1.0 |
| 17H Learning and memory | 85 | 59.7 | 1.5 |
| 40H Bacterial pathogenesis | 65 | 63.5 | 1.5 |

**Table 2.** Effects in Model 1 including stages 2 and 3 combined.

| Parameter | Iteration 1 | Iteration 2 | Iteration 3 |
|---|---|---|---|
| ***Estimates of fixed effects*** | | | |
| Intercept (transformed exam score) | 0.133 ± 0.108 (-0.082 – 0.348) | 0.134 ± 0.107 (-0.079 – 0.347) | 0.115 ± 0.105 (-0.094 – 0.324) |
| Gender | 0.003 ± 0.046 (-0.087 – 0.093) | *Excluded* | *Excluded* |
| Nationality | 0.187 ± 0.072 (0.046 – 0.328)** | 0.187 ± 0.072 (0.046 – 0.328)** | 0.196 ± 0.071 (0.056 – 0.336)** |
| Disability | 0.189 ± 0.054 (0.082 – 0.296)*** | 0.189 ± 0.054 (0.082 – 0.296)*** | 0.196 ± 0.054 (0.090 – 0.302)*** |
| Total minutes delivered | 0.000 ± 0.000 (0.000 – 0.000) | 0.000 ± 0.000 (0.000 – 0.000) | *Excluded* |
| Number of views | 0.005 ± 0.003 (0.000 – 0.010) | 0.005 ± 0.003 (0.000 – 0.010) | 0.003 ± 0.002 (-0.001 – 0.006) |
| ***Estimates of random covariates*** | | | |
| Module | 0.025 ± 0.015 | 0.025 ± 0.015 | 0.024 ± 0.015 |
| Intraclass correlation | 0.050 | 0.051 | 0.051 |
| Aikake Information Criterion | 1435 | 1431 | 1415 |

Note: estimates and SEM are shown. Values in brackets are 95 % confidence intervals. **P < 0.01; ***P < 0.001.

**Table 3.** Effects in models considering stages 2 and 3 separately.

| **Parameter** | **Stage 2** | **Stage 3** |
|---|---|---|
| ***Estimates of fixed effects*** | | |
| Intercept (transformed exam score) | 0.062 ± 0.171 (-0.298 – 0.422) | 0.154 ± 0.113 (-0.070 – 0.377) |
| Nationality | 0.175 ± 0.105 (-0.032 – 0.382) | 0.227 ± 0.089 (0.052 – 0.401)* |
| Disability | 0.196 ± 0.078 (0.042 – 0.350)** | 0.206 ± 0.071 (0.066 – 0.346)** |
| Number of views | 0.003 ± 0.002 (-0.001 – 0.008) | 0.002 ± 0.002 (-0.002 – 0.006) |
| ***Estimates of random covariates*** | | |
| Module | 0.043 ± 0.039 | 0.004 ± 0.006 |
| Intraclass correlation | 0.087 | 0.011 |
| Aikake Information Criterion | 939 | 463 |

Note: estimates and SEM are shown. Values in brackets are 95 % confidence intervals. **P < 0.01; ***P < 0.001.

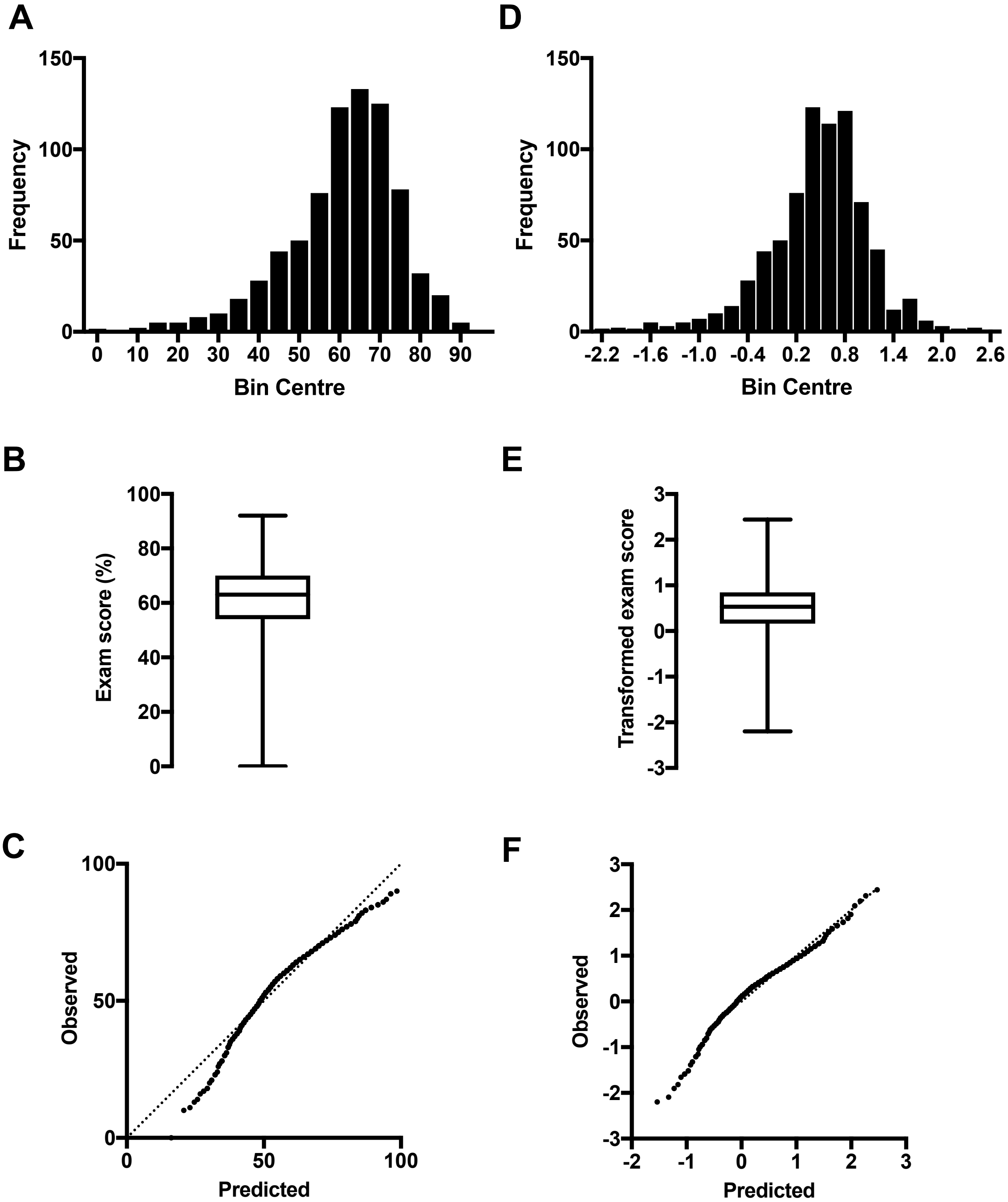


**Figure 1.** Distribution of raw and transformed data. (A) Frequency distribution of exam marks with 5 % bin centres. (B) Box and whisker plot of exam marks. (C) QQ plot of exam marks. (D) Frequency distribution of logit-transformed fractional exam marks with 0.2 bin centres. (E) Box and whisker plot of logit-transformed fractional exam marks. (F) QQ plot of logit-transformed exam marks. Box plot whiskers show minimum and maximum values; horizontal lines show 75th, 50th, and 25th percentile values.

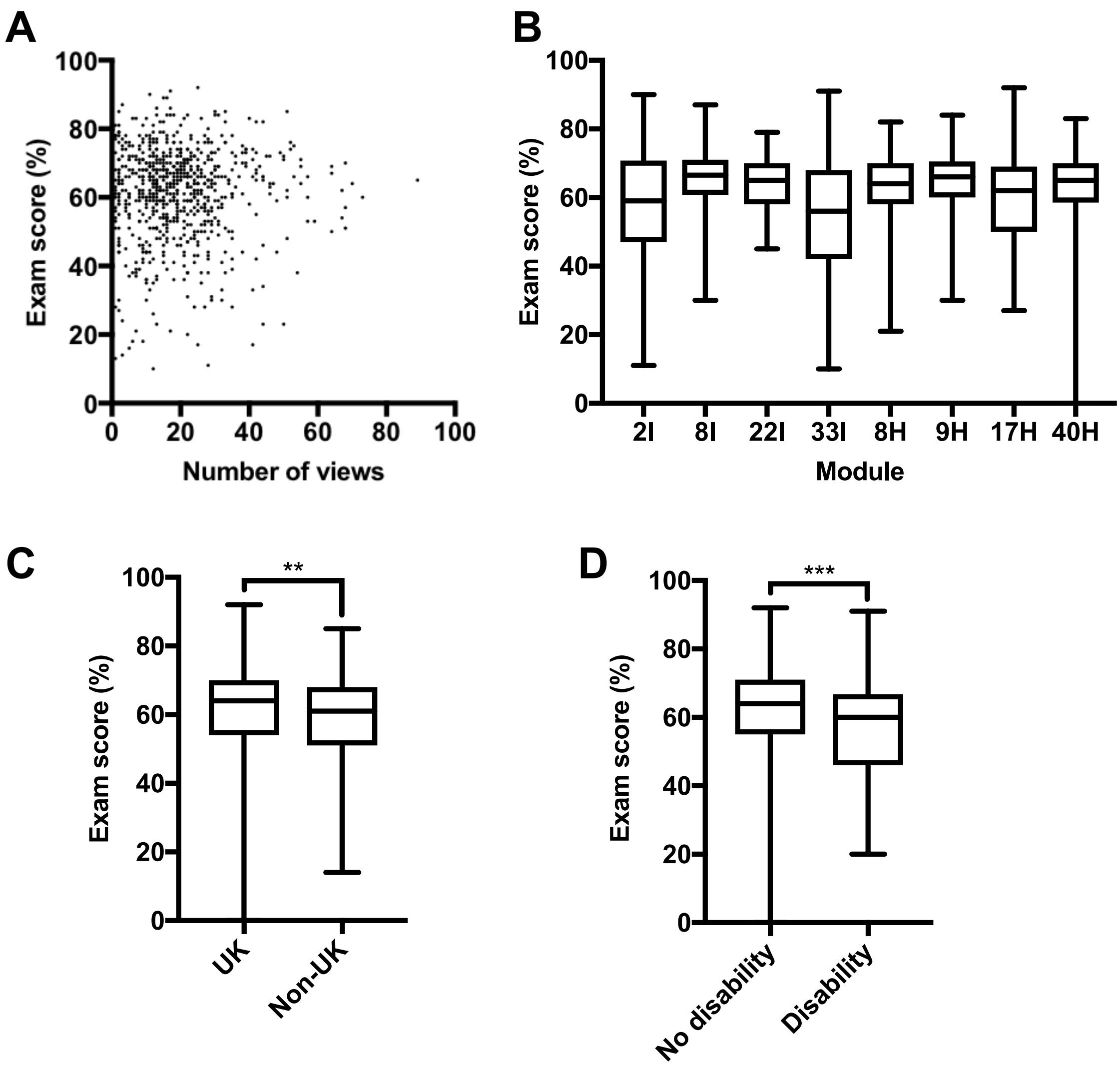


**Figure 2.** Lecture capture usage is not predictive of examination performance. (A) Scatter plot showing relationship between number of lecture capture views and exam score. (B) Box and whisker plot of exam score across each module. 2I Immunology, 8I Molecular biotechnology, 22I Species-environment interactions, 33I Mechanisms of genetic change, and stage 3 modules: 8H Cancer and the cell cycle, 9H Cell and tissue engineering, 17H Learning and memory, 40H Bacterial pathogenesis. (C) Box and whisker plot of exam score for UK vs. non-UK students. (D) Box and whisker plot of exam score for students without a disability vs. those with a declared disability. Box plot whiskers show minimum and maximum values; horizontal lines show 75th, 50th, and 25th percentile values.

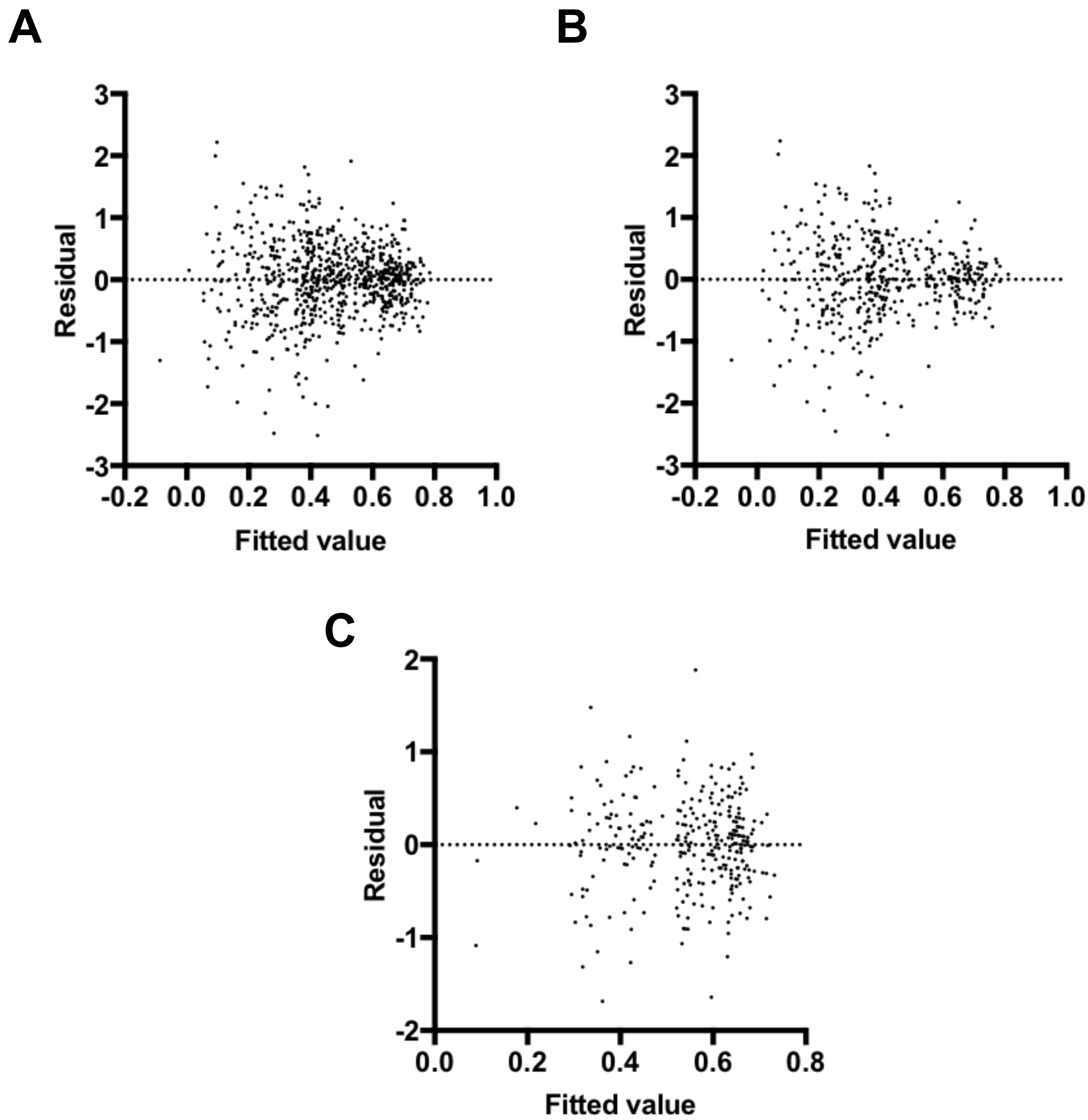


**Figure 3.** Plots of residuals vs. fitted values give random distributions without major outliers. (A) Residuals vs. fitted values for full model including students from stages 2 and 3. (B) Residuals vs. fitted values for model including students from stages 2 only. (C) Residuals vs. fitted values for full model including students from stage 3 only.