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## RESEARCH ARTICLE

# University Mathematics Assessment Practices During the Covid-19 Pandemic

Matthew Henley, School of Mathematics, University of Birmingham, Birmingham, United Kingdom.

Email: mhenley98@gmail.com

Michael Grove, School of Mathematics, University of Birmingham, Birmingham, United Kingdom.

Email: m.j.grove@bham.ac.uk

Rachel Hilliam, School of Mathematics & Statistics, The Open University, Milton Keynes, United Kingdom. Email: rachel.hilliam@open.ac.uk

## Abstract

In response to the global Covid-19 pandemic departments of mathematical sciences within the UK and Ireland needed to adapt their teaching approaches and methodologies from March 2020 to incorporate not only government social distancing requirements, but also periods of national lockdown and the fact that students were necessarily studying online. In planning for the many different and possible scenarios, universities implemented a range of emergency measures and regulation changes to provide frameworks for adapting teaching, learning and assessment approaches, and at a subject level, departments also needed to correspondingly respond to specific disciplinary needs. Here we specifically consider the changes made by mathematical sciences departments to their assessment practices in the period from March 2020 until January 2021 and their proposed adjustments for the remainder of the 2020/21 academic year. We found that departments were using a range of different approaches regarding the release of their assessments and this paper considers the implications of each for future practice. In particular we identified a concerning issue that emerged across a number of departments in relation to academic misconduct that will now require a community-wide approach if open-book online assessments are to prove a valid, reliable and fair method of assessment in the longer-term.

**Keywords:** Assessment, Covid-19 adjustments, Academic integrity, Open-book assessment.

## 1. Introduction

The Covid-19 pandemic has resulted in unprecedented challenges for every sector and industry. The education sector has been significantly impacted, with many schools, colleges and universities unable to accommodate teaching and learning in their usual way. For example, in March 2020 a UK-wide national lockdown was announced which encompassed the remainder of the 2019/20 academic year; during this period all on-campus learning activities, including in-person examinations, were affected. For the 2020/21 academic year, whilst in-person learning may have been initially allowed by government, many institutions chose to deliver their provision either in-part, or entirely online. As the pandemic evolved, further periods of lockdown were enforced throughout 2020/21, necessitating universities to constantly re-evaluate their teaching, learning, assessment and support practices.

Many universities moved at least in part to 'online delivery', unable to welcome their students onto their campuses as they do normally. The way in which university mathematics departments facilitated 'online learning' is of particular interest, since historically, "*[fully online] mathematics instruction has not been successful in comparison with traditional [face-to-face] mathematics instruction*" (Trenholm, Peschke and Chinnappan, 2019). To determine exactly how university mathematical sciences departments navigated this transition, a large-scale survey was conducted to identify the different approaches taken by departments regarding teaching and assessment.

One of the main concerns identified within the responses to the survey related to assessment. Trenholm and Peschke (2020) highlight the nature of assessment as one of the main differences between online and face-to-face mathematics courses. In face-to-face mathematics courses, the dominant form of assessment has been in-person, invigilated examinations (Iannone and Simpson, 2012). For many institutions, in-person examinations were infeasible during the pandemic and so it is of particular interest to explore the alternative arrangements used and their implications for future practice. This paper primarily focuses on the assessment arrangements used by departments and includes their experiences of implementation.

## 2. Research Methodology

A survey was conducted of UK mathematical sciences departments between December 2020 and February 2021. It focused upon the immediate changes in teaching and learning practices necessitated by the rapid onset of the pandemic, explored changes implemented during the first half of the 2020/21 academic year and proposed changes to examination practices for the entire 2020/21 academic year. The range of topics included teaching arrangements (in particular, arrangements for lectures, problem classes, tutorials, computer lab sessions, group work and optional modules), as well as exam arrangements, student experience and future departmental teaching and learning plans. The full questionnaire was analysed as part of an undergraduate final year project, however, this paper chooses to focus particularly on the changes to examination practices in 2019/20 and 2020/21.

The survey was targeted at Heads of Department, Directors of Teaching, or similar individuals, of all UK higher education institutions with mathematical sciences departments who would have an overview of the teaching and learning practices within their departments.

One of the main areas of concern identified through the survey was that of academic misconduct amongst students. Therefore a short follow-up survey was also conducted to investigate this aspect further asking departments to identify the extent to which they experienced instances of academic misconduct in 2020/21 and to detail any mitigating measures taken. The follow-up survey was sent, in February/March 2021, to all departments who indicated that they were happy to be contacted with further questions in the initial survey. The results from this follow-up survey are also reported here.

### 2.1. Research Ethics

Ethical approval for this survey and study was granted by the University of Birmingham and appropriate ethical guidelines (BERA, 2011) were followed throughout.

In particular, once all survey responses had been received, respondents' names and contact details were removed from the data set. Any references made in responses that might identify any individual or institution were also removed. Responses were then numbered such that answers to individual questions could be linked, as a department's answer to one question might provide additional context relating to another.

### 2.2. Data Cleansing

Two responses were received from the same university, one from its mathematics department and the other from department not classified as mathematical sciences by HESA, (the Higher Education Statistics Agency) (HESA, n.d.(a)). As this study only concerns departments of mathematical sciences, this second response was removed from the data set.

All responses were checked to ensure they had been provided by appropriate members of staff in each department with knowledge of the departmental teaching and learning practices in 2020/21. Responses were also checked for their completeness. In both instances, no modifications to the original dataset were required.

### 2.3. Response Rate

After data cleansing, there were 37 valid responses to the initial survey representing institutions from all nations of the UK and Ireland. Seventeen of these responses came from departments within the research-intensive Russell Group universities. Seven came from departments at Post-1992 universities, and five were received from universities that used to belong to the 1994 Group, but which are now unaligned to any mission group. As Grove, Croft and Lawson (2019) explain, the 1994 Group was an alliance of smaller research-intensive universities, but the group dissolved in 2013 after several of its members joined the Russell Group. We have decided to follow their example and categorise these 5 universities as 'unaligned\*', in recognition of the fact that they are research-intensive. The remaining 8 responses came from departments unaligned with any mission group.

To ascertain the proportion of mathematical sciences students represented by the survey, data were taken from HESA. HESA provides a breakdown of the numbers of students enrolled in courses of mathematical sciences at all institutions of higher education each year in the UK. The most recent academic year for which comparable HESA data were available at the time of analysis was the 2018/19 academic year (HESA, n.d.(b)). HESA provides the individual numbers of undergraduate, postgraduate taught and postgraduate research students enrolled that year. As this study concerns adjustments to teaching (and assessment) provisions, the numbers of postgraduate research students were not of interest, and thus only the data for undergraduate and postgraduate taught students are considered.

In the 2018/19 academic year, HESA recorded a total of 42,790 undergraduate and postgraduate taught mathematical sciences students enrolled across 93 institutes of higher education in the UK. The 37 departments that responded to the survey accounted for 27,925 of these 42,790 students, which equates to approximately two thirds of the taught mathematical sciences student population within the UK.

## 3. Results and Analysis

The results reported here form the responses to the original survey regarding examination arrangements. Specifically departments were asked to detail their assessment mechanisms for the 2020/21 academic year, and then compare these to the emergency arrangements introduced at the end of the 2019/20 academic year. The analysis of these responses then resulted in a follow-up survey which explored in greater depth the theme of academic misconduct thereby providing a richer qualitative dataset which we report below.

### 3.1. Examination Arrangements

In the initial survey, detailed questioning focused upon:

1. Whether exams were, or would be, sat on-campus or remotely.
2. The form of the examination (for example, whether students needed to hand-write answers to traditional-style exam papers or problem sheets or complete an online quiz or assessment).
3. The time period given for students to complete assessments.

#### 4. Whether students had flexibility in when to complete their assessment.

From the respondents, 36 departments answered this question. All 36 responses indicated that assessments were, or at least expected to be, completed remotely.

On the format of assessment, one response indicated that arrangements varied across all modules, with different formats and different time constraints being used. A second response again indicated that the format of the assessment differed across modules and was left to the module leader to decide, but that students would have 24 hours to complete the assessment in accordance with university policy. The remaining 34 departments all indicated that, for at least part of the assessment of some modules, students were required to complete a written assessment, that is students write and upload solutions to a traditional-style exam paper, problem sheet or similar form of coursework.

The time periods, and flexibility, in which students had to complete this written assessment varied amongst departments, but can be grouped into four broad categories:

- 16 of the 34 departments (47%) were categorised as using a 'short release' format, whereby students had a similar amount of time to write solutions as they would have in an invigilated, on-campus exam, plus an additional 20-60 minutes for electronic upload.
- 3 departments (9%) were categorised as using an 'intermediate release' format, whereby students had a period of 6-9 hours to write and upload solutions.
- 7 departments (20%) were categorised as using a '24-hour release' format, whereby students had 24 hours (or 23 hours in one department) in which to write and upload solutions.
- 4 departments (12%) were categorised as using a '48-hour release', whereby students had 48 hours in which to write and upload solutions.

Four departments (12%) could not be categorised as following any one of these approaches. Two departments were yet to decide upon the time that they would allow for their written assessments at the time of the survey. The third indicated that they were using pieces of continuous assessment and typically allowed 7-10 days for students to complete each piece. The remaining department indicated that, for undergraduate students, they were allowing 3 hours, just as they would in a normal exam, plus 90 minutes for scanning and uploading, plus a further 90 minute late penalty period; any solutions submitted within this final 90 minutes of the total 6 hour time frame would be subject to a 10 mark penalty. They added that they were following the 24-hour format for postgraduate exams.

It is also worth noting that one of the departments categorised as using a 24-hour release format indicated that they were using the short release format for Year 1 students, but the 24-hour release format for all other year groups, hence their overall categorisation.

In addition, another department following the 24-hour release format, which was the default arrangement for their whole university, requested institutional permission to use a short release format instead. However, by the time permission was granted, the department considered it too short notice to implement as doing so would be unfair on students.

Two departments using the short release format explicitly mentioned minimising the risk of academic misconduct as one of their reasons for doing so. One of these had followed the 24-hour release format at the end of the 2019/20 academic year, but reduced the timings in the current academic year "*due to grade inflation and cheating*" (Respondent 12).

Another department reported “*about a dozen cases of plagiarism*” when following the 24-hour format in the previous academic year. Interestingly, this department was undecided on whether to move to the short release format or follow the 24-hour format again but “*spend more time in designing questions where it is impossible to Google the answer*” (Respondent 4).

Additionally, one of the departments using an intermediate release format commented that in the previous academic year, some modules used a 24-hour exam, whereas others opted for 7-day coursework. Under these arrangements, the department said that “*there were clear cases of the questions being asked (and answered) on the internet*” (Respondent 3). Thus, several departments identified cases or concerns of academic misconduct when students had longer to complete written assessments.

Evidently, the most common approach used for written assessments was the short release format. One possible explanation for this could be concerns associated with the potential for academic misconduct by students. Academic integrity is of great importance for universities as Trenholm (2007) argues:

*“Fundamentally, administrators and faculty acting as agents in society are responsible for producing a skilled and educated graduate. They are responsible to ensure that the paper certificate or degree accurately reflects the student’s ability.”*

Universities must ensure that the degrees they award preserve their academic integrity and are respected by employers and society. The arrangements of departments are thus of particular interest, since on-campus, closed-book, invigilated exams are ordinarily the dominant form of assessment used within the mathematical sciences (Iannone and Simpson, 2012). Rovai (2000) argues that “*online instructors must recognize the need to design instruction appropriate to the medium*” and, in particular, Trenholm (2007) identifies that it is commonly thought that every online assessment should be regarded as being open-book.

### **3.2. Academic Misconduct**

Given the concerns raised by several departments in relation to student academic misconduct, it was decided that further investigation would be beneficial. In the initial survey, 34 of the 37 respondents indicated that they were happy to be contacted with further questions and so these 34 respondents were sent three additional questions for response via email. Thirteen responses were received to this follow-up survey; eight came from departments at Russell group universities, two from departments at post-1992 universities, two from our categorised ‘unaligned\*’ universities, and one from an unaligned university. For each responding department, the responses to these additional questions were then combined with those from the original survey.

Respondents were asked if they had identified any of the three following categories of academic misconduct in any of their online assessments: (1) plagiarism arising from the improper use, or referencing of, third party sources; (2) collusion (students working together and sharing answers or ideas); and, (3) contract cheating. Respondents were asked to provide qualitative details on the nature of the misconduct, as well as the number of such instances where possible.

Twelve departments responded to this question detailing the number of instances of academic misconduct that they have identified. Only one response indicated that no instances of academic misconduct had been identified, but of the remaining 11 respondents, eight indicated that they had identified cases of plagiarism between March 2020 and March 2021. One department commented that “*this was to be expected since exams are now not just ‘open book’ but ‘open internet’*” (Respondent 21). One department said that they had identified 15 cases of plagiarism during their first semester of the 2020/21 academic year, and a second commented that around 10% of students

taking one module had been identified as having submitted plagiarised work in some form during the June 2020 exam.

All 11 respondents who reported that they had identified cases of academic misconduct indicated that at least some of these were in the form of collusion. One respondent reported that 40% of students in one module were suspected of collusion. A second respondent reported 11 suspected cases of collusion during semester 1. Another department reported that 16 out of 47 students taking one module admitted to collusion. Whilst collusion was only identified in some modules by departments, and indeed no data were sought on the baseline level of collusion in pre-Covid years, the extent of it within these modules raises the question of whether it also occurred in other modules but was not detected.

With regards to contract cheating, five respondents indicated that they had found cases of their exam questions being posted on online 'study support' websites, with a sixth department commenting that they had suspicions of contract cheating but these could not be proven. However, one of these departments made the point that they could not be sure if these were cases of cheating or if students had "*sought answers after the examination simply for reassurance*" (Respondent 31). A second department commented that they had found 500 of their exercises on various 'study support' websites, and that:

*"This term, 15 students (out of about 250) in one year cohort have been identified as posting questions...(and all of whom have now admitted to doing so)." (Respondent 34).*

Another department reported just over 80 cases of academic misconduct in their January 2021 assessment period and whilst these were still being investigated, the respondent (Respondent 5) indicated that these cases were "*probably roughly equally split*" between the three identified forms of misconduct, namely plagiarism, collusion, and contract cheating.

A fourth department commented that they identified one instance of contract cheating in their January 2021 examinations, but the issue became "*much more extensive for [their] in-course semester 2 assessments*" where instances of contract cheating were identified in all year groups (Respondent 28).

One respondent commented that academic misconduct "*appears to be getting more common*" (Respondent 7). In contrast, another department who identified cases of plagiarism and collusion in their assessments reported that these were not identified "*at a rate that is any more frequent than in non-Covid years*" (Respondent 25). However, it should be noted that this department later added:

*"Our course is heavily weighted towards coursework, and our exams are usually open book ... so most of our assessment is already designed in a way that is fairly robust against such malpractice." (Respondent 25).*

Trenholm (2007) argues that academic misconduct is more common in online assessments:

*"[Due to] the anonymity that the Internet affords ... students, who in a traditional classroom may never consider cheating, may find the temptation to do so in an online course too powerful to resist".*

These concerns raised by respondents coincided with the publication of a research article on contract cheating in STEM (Science, Technology, Engineering and Mathematics) subjects during the pandemic (Lancaster and Cotarlan, 2021). Contract cheating is the term used to refer to cases of students engaging someone else to provide answers on their behalf. This study by Lancaster and Cotarlan (2021) analyses the use of one 'study support' website by students for contract cheating.

Their study identifies an increase of 196% in the numbers of contract cheating requests across five STEM subjects between the time periods April 2019 to August 2019 and April 2020 to August 2020. As noted by Lancaster and Cotarlan (2021), this increase coincides with the move to online assessments as a result of the Covid-19 pandemic. Whilst it should be noted that mathematics was not one of the subjects considered, the findings within this report are nevertheless stark and of direct relevance to mathematical sciences departments.

This raises the question of how assessments can be designed to minimise the risk of academic misconduct, which we now consider.

### 3.3. Upholding Academic Integrity

In the initial survey, departments were asked to what extent they considered and implemented question randomisation in their assessment framework. The responses of all departments are shown in Table 1. The figures are presented according to the length of time students had to complete their written assessments. The number of departments who considered and implemented question randomisation but were not categorised as using a certain release format, or indeed as using written assessments at all, are shown in the row titled ‘unclassified’.

Release format	Extent to which departments considered and implemented question randomisation			Total
	Did not consider	Considered but not implemented	Considered and implemented	
Short release	6	3	7	16
Intermediate release	1	0	2	3
24-hour release	0	3	4	7
48-hour release	0	2	2	4
Unclassified	2	1	4	7
<b>Total</b>	<b>9</b>	<b>9</b>	<b>19</b>	<b>37</b>

Table 1: The extent to which departments considered and implemented question randomisation in their assessment framework (n=37).

From Table 1, it can be seen that just over half of the respondents indicated that their departments implemented question randomisation to some extent. However, departments were not explicitly asked in what context it was being used. Thus, it is not clear whether these departments were using question randomisation in their written assessments or as part of online quizzes, or whether randomisation was being used across the entire department or within only a few modules. Two departments did though indicate they were using question randomisation as part of their written assessments. One of these was following a 24-hour release format and indicated that they “*create several versions of each exam to mitigate against collusion*” (Respondent 27).

To obtain a sense of how departments were using question randomisation, departments were asked, as part of the follow-up survey, to confirm whether they were using question randomisation and if so, for what purpose. Twelve responses were received to this question. Four respondents indicated that they were only using randomisation in online quizzes. One of these four departments commented that they considered question randomisation as “*not really appropriate for an end of module exam*” (Respondent 21). In contrast, another of these four departments (Respondent 5) said that they were

“*looking into*” using randomisation in written assessments if they continue to be online in the 2021/22 academic year.

Three different departments indicated that question randomisation was being used in a very small number of written assessments, as well as in some online quizzes, with one department commenting that “*most of [their] lecturers won’t go through the trouble of [randomising written assessments]*” (Respondent 4). On the other hand, another of these three departments (Respondent 14), who indicated that “*a very small number of course units had a randomised take-home exam [with] a small number of variants of papers*”, went on to say that:

“*We were concerned about the workload in setting these up ... and possible confusion in marking, but it turned out to be much easier than we thought.*” (Respondent 14).

Another department indicated that they were using randomisation for all questions in their stage 1 (first-year) exams, but that “*at stage 2+ [they] don’t consider randomisation so useful, as the underlying method to a problem is the same*” (Respondent 31). One other department reported they created 8-10 variants of every exam paper, “*with changes such as notation, numeric parameters [or] different choices of function to consider*” (Respondent 27). They noted that whilst that this did take more time to set up and check, they recommended the use of LaTeX Macros. One strategy proposed by three departments involved students using digits from their unique student ID number in numerical questions. These responses perhaps suggest that randomisation within written assessments may not be as cumbersome as departments imagine.

Question randomisation is just one of the ways of reducing the risk of misconduct identified by Clark et al. (2020) and so it is of interest to see if departments have been utilising other approaches. Therefore, the final question of the follow-up survey explored whether departments had taken other specific actions to prevent academic misconduct amongst their students. Nine responses were received and can be grouped into the following themes:

- Changes to assessment duration.
- Individualisation of assessment materials.
- Increasing student awareness of academic misconduct and its implications.
- Using vivas and oral assessments.

### 3.3.1. *Changes to assessment duration*

One department stated that an approach to minimise the risk of misconduct was using a short release format for written assessments. A second department commented that they had tried to shorten the exam duration for their summer exams from 48 hours, but were prevented by centralised university policies. However, whilst reducing the assessment duration appeared to help some departments, one respondent referenced a report made by one of their students that six or seven other students had quite an extensive plan for collusion in place for several short exams:

“*These students were supposed to have divided up exam questions between themselves for the first hour or so of the examination, shared findings between themselves, then spent the remaining 90 minutes copying from other solutions.*” (Respondent 31).

Indeed Rovai (2000) notes that “*timed tests that reduce the opportunity to cheat also help*” in addressing misconduct, even in standard time assessments, cheating can still occur. Similarly, Lancaster and Cotarlan (2021) argue that “*there is nothing to stop students posting questions online and receiving answers within the time frame of an exam*”. Indeed, one such online ‘study support’

website popular amongst students confirms that they seek to answer posted questions within two hours and on average, do so in well under an hour.

### 3.3.2. *Individualised assessment materials*

Only allowing standard time for online examinations in itself is not enough to eliminate the risk of contract cheating and it is therefore necessary for departments to consider other measures too. One such measure identified by Clark et al. is “*watermarking exam materials to make them more difficult to share with contract cheating providers*”. One respondent indicated that they are currently “*developing technology to provide individually watermarked papers*” (Respondent 5). Unfortunately, this solution again might be compromised by students simply re-typing the question themselves to shed the watermark, though this would take more time.

### 3.3.3. *Increasing student awareness of academic misconduct and its implications*

A more common action, taken by six of the departments who responded, was simply to increase their communication with students regarding acceptable exam conduct and the penalties for cheating, highlighting both theoretical and real examples of where these had been imposed. One innovative example involved collaboration between a department and their undergraduate mathematics society. The society “*manage a discord server in which students often discuss individual modules, including their assessments*” (Respondent 34). The society had agreed to suspend the discussion areas for modules during summer assessments and to report any suspicious activity or messages to staff.

Whilst Rovai (2000) identifies several other measures that can reduce the risk of cheating, they conclude that:

*“Arguably, the best approach is to identify the issue of plagiarism openly with the aim of affecting learner attitudes and values.”*

This approach has also been shown to be somewhat effective by a survey conducted by King, Guyette and Piotrowski (2009). Here, students studying business indicated that they would be less likely to cheat if they had specifically been told that it was not allowed. Thus, a focus by departments of better educating students on the nature and implications of academic misconduct should not be overlooked.

### 3.3.4. *Using vivas and oral assessments*

One department reported that they used a significant number of viva examinations, oral examinations in which students have to defend their work, at the end of the 2019/20 academic year and would likely do so at the end of the 2020/21 academic year “*to establish authorship of the submissions received*” where there were doubts (Respondent 33).

### 3.3.5. *Discussion: potential approaches to upholding academic integrity*

Approaches for upholding academic integrity in online examinations have been suggested by Clark et al. (2020). One approach suggested, which lends itself well to statistics and some applied mathematics modules, is using unique data sets for each student. This would mean it would not only be more difficult for students with different questions to collude, but also, if questions are posted online, the student with that allocated data set can be traced. However, creating unique data sets for each student is quite extensive and unlikely to be appropriate for pure mathematics modules. But even on a lesser scale, question randomisation has been identified as an effective means for reducing the risk of academic misconduct (Rovai, 2000). Other examples of how questions might be

randomised include changing coefficients in equations and expressions, or specifying different inputs for given algorithms.

Another solution identified by Lancaster and Cotarlan (2021), but which none of the respondents to either the initial or follow-up surveys indicated that they were pursuing, involves the proctoring of online assessments. In 2007, before online examinations were commonplace, Trenholm (2007) argued that proctoring was in fact the only way of eliminating the risk of cheating in online examinations. Understandably, the transition for many departments from on-campus, closed-book, invigilated exams to remote, open-book assessments was difficult enough without the added complication of organising online invigilation too. However, one department did comment that:

*“Worryingly, we have no way of making sure they [students] are not talking to each other during the exam.”* (Respondent 21).

Whilst proctoring would provide a way of ensuring students cannot collude or cheat by any other means in an exam, it raises other concerns. A rapid review of e-proctoring by Eaton and Turner (2020) identified that some students said they felt increased levels of anxiety due to e-proctoring. One reason they identified for this is that certain behaviours, such as *“looking away from the screen for more than a few seconds ... or having another person enter the camera frame”*, which might be perfectly innocent, can signal academic misconduct and result in disqualification. Furthermore, their review quotes cases of students *“vomiting into wastepaper bins on camera during the exam because they were not permitted to leave the room”*. Thus, while e-proctoring has the potential to mitigate the risk of academic misconduct, it raises significant concerns for students’ mental health and therefore careful consideration must be made before employing it.

Several approaches to minimising the risk of academic misconduct have been identified from our own survey and within the published literature, however none appear to eliminate the risk completely. Given the importance of academic integrity and the threats posed to it by academic misconduct in an online assessment age, the extent of the misconduct and the ways in which mathematical departments can mitigate against it are therefore worthy of further study. In addition, universities themselves must have a pivotal role in assisting individual departments in ensuring the academic integrity of their assessments.

## 4. Discussion

Given that using a short release format for assessments has been identified as one way of reducing students’ opportunity to cheat, it is interesting to consider why departments opted for longer release formats for their assessments in the first place. Reasons that departments gave in the initial survey for using a 24-hour release include:

*“Due to access concerns, and how tight time limits might negatively affect certain groups, we felt that it would not be right to impose significant time constraints on exams.”*  
(Respondent 34)

*“Students have indicated to us they [24 hour exams] reduce the pressure and better help them with their learning.”* (Respondent 28)

*“Having longer to do the exam meant the scripts were much neater, and were a better test of their true mathematical abilities.”* (Respondent 27)

This raises some interesting questions that merit further study to explore the tensions that exist between short-release assessments that minimise the potential for academic misconduct, and

longer-release assessments that students feel provide a better measure of their true mathematical ability and which reduce their exam stress and anxiety.

During the Covid-19 pandemic, it is likely that some international students will have studied and completed assessments in different countries and hence different time zones. Arguably a 24-hour release is a better way to accommodate these students. One department who were using a short release format commented that all exams start at 1pm UK time, with no allowances for time zone, which the respondent themselves identified as an ongoing concern. An alternative being used by several departments was to allow different start times in different time zones. This too has potential issues, particularly if the same examination papers are being used since students could share questions with those who are yet to start the assessment in their time zone. Using a 24-hour release instead means that examination papers can be released at the same time across the world without the potential problem of students in certain time zones having to stay up through the night to complete a 3-hour exam. A longer-release format is also more inclusive since it better takes into account individual student circumstances, particularly for those students who might normally receive additional time.

Whilst there are several valid reasons as to why departments might opt for a longer release format, one obvious concern is that of grade inflation. As Respondent 12 commented, using a 24-hour release format led to “*grade inflation and cheating*”, however as previously stated cheating can still occur in short release exams. Conversely, Respondent 28, whose department was using the 24-hour release format, commented that “*mark profiles appear to be tracking traditional assessments*”. It is though worth noting that this responded also added:

*“We have made a transition from ‘marking’ to ‘grading’ which is more pedagogically appropriate for open-book and extended-time assessments since it considers the strengths and weaknesses of the submitted work as a whole.”* (Respondent 28)

Indeed Respondent 1 whose department were using a 48-hour release format, also claimed that student attainment was similar to when using traditional assessments although they identified a slight increase in grades of the most able students. These comments are in line with a small study conducted by Phiri (1993) which sought to make a comparison between mathematics assessment by closed-book and open-book tests. The study found that whilst the two methods of assessment result in comparable grades, open-book assessments provide a better discriminator between students. In particular, the average mark in the open-book tests was slightly lower than in the closed-book tests, but the range of marks and standard deviation of the grades obtained in the open-book tests were significantly greater than in the closed-book tests.

To summarise, two departments using longer release formats indicated that student attainment was similar to that in previous years, perhaps rebutting the concern that longer exams might lead to grade inflation. However, this issue is again one meriting further investigation.

## 5. Conclusion

This study sought to identify the practices being used by departments of mathematical sciences for teaching and assessment purposes during the Covid-19 pandemic. Whilst teaching arrangements were considered in the survey, they are not reported here. Instead, we have focused upon assessment practices since they form an area of particular concern within the mathematical sciences during the Covid-19 pandemic. It has been identified that departments are using a range of assessment approaches, and our survey shows this diversity with no one form of assessment being identified as optimal. There are arguments in support of short-release exams, in particular that they reduce the chance for students to cheat, although evidence shows that this can still occur. On the

other hand, longer release exams are more inclusive of students' individual circumstances. However, there exists evidence of an increase in reported instances of academic misconduct and in particular contract cheating by students within mathematical sciences departments. Whilst we have identified various measures that can be taken to discourage and minimise this misconduct, there does not appear to be one single method of eliminating this issue entirely. Whilst e-proctoring is one solution many universities are currently considering, it is not without its own ethical concerns. The question of how best to address academic misconduct, and hence ensure the integrity of university-level assessments, is one that requires further consideration across the entire higher education sector, particularly if online assessment practices continue to be utilised in the future.

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