

## Getting to Grips with Online Mathematics Education During the COVID-19 Pandemic

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### ABSTRACT

The COVID-19 pandemic necessitated a move to emergency remote teaching in many universities across the globe, beginning in the early months of 2020. As a result, lecturers and students had to transition to an online form of education at very short notice. Due to the symbolic nature of the subject, online education in mathematics presented additional challenges, in terms of representing mathematical notation and communicating effectively with students online. In May 2020 and again in May 2021, we undertook an anonymous online survey of mathematics lecturers in higher education, aiming to investigate their experience of emergency remote teaching and any changes to their practice as a result. We received 257 and 190 responses respectively, and respondents were based in 30 countries, primarily in Europe. They reported on the types of hardware and software they used; whether they opted for live sessions or pre-recorded; the main challenges they and their students faced; and the changes to assessment necessitated by the move online. In this paper, we report upon their reflections of their journeys in online teaching, as they compare their initial experiences of emergency remote teaching with their approaches one year on.

### KEYWORDS

COVID-19, mathematics education, higher education, online teaching

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### PLEASE CITE AS

Ní Fhloinn, E. & Fitzmaurice, O. (2022) Getting to Grips with Online Mathematics Education During the COVID-19 Pandemic In E. Costello, P. Girme, D. Hyland, T. Kaur, O. Kelly, T. McLoughlin, & P. Van Kampen (Eds) Proceedings of the CASTeL 9th STEM Education Research Conference (18-28) Dublin City University. <https://doi.org/10.5281/zenodo.6778365>

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## Introduction

From around March 2020, the COVID-19 pandemic necessitated a move to emergency remote teaching (Hodges et al., 2020) in higher education across the globe. This meant that students and educators had to pivot to online teaching at very short notice, with little to no time to prepare or source the necessary hardware or software. Teaching mathematics online presents particular challenges in this regard, due to the symbolic nature of the subject and the difficulty in representing mathematical notation in many commonly-used software systems (Engelbrecht & Harding, 2005).

In May 2020, and again in May 2021, we undertook an anonymous online survey of mathematics lecturers in higher education, aiming to investigate their experience of emergency remote teaching and any changes to their practice as a result. We received 257 and 190 responses respectively, from 30 countries. The results of the earlier survey have been reported in a number of journal articles (Fitzmaurice & Ní Fhloinn, 2021; Ní Fhloinn & Fitzmaurice, 2021b, 2021c, 2021a) and explored issues such as the types of technology used; whether sessions were conducted live or pre-recorded; the main challenges faced; and the changes lecturers made to their assessments in order to conduct them remotely. Extensive literature reviews of the corresponding areas can be found in each of the above papers, along with detailed discussions of the results. While these reported on a snapshot in time, in which lecturers had about three months' experience of emergency remote teaching (often in lockdown conditions), it was of interest to explore their experiences in further detail one year on, as many were still teaching remotely. During the academic year of 2020/2021, many mathematics lecturers were engaged in what would be more accurately termed blended (Graham, 2006), hybrid (Snart, 2010) or distance learning (Moore et al., 2011), but for clarity for the respondents of the survey, we called this “online learning” and will use this term throughout.

Although we cannot accurately measure the overlap between the samples in the two anonymous surveys, we can make some overall observations about trends in their responses. Therefore, in this paper, we consider the following research questions:

- How do mathematics lecturers describe their experience of online teaching by May 2021?
- Is there any evidence of a shift in their reported experience between May 2020 and May 2021?

## Methodology

### *Survey design and analysis*

The surveys used in this study were purpose-designed, as nothing similar existed at the time. They were piloted with a group of experienced mathematics lecturers prior to distribution, and changes were made based on their feedback. The second survey, undertaken a year after the first one, made use of many of the same questions, amended to reflect the passage of time. Ethical approval was granted by the first author's university.

The anonymous online survey reported on here was issued using Google Forms in May – June 2021. It was distributed via a number of mailing lists for mathematicians, as well as highlighted at relevant online mathematics education conferences and workshops. The quantitative data was analysed using Excel and general inductive analysis (Thomas, 2006) was used for the qualitative data.

### *Survey sample*

The profile of survey respondents is shown in Table 1. The age profile is as might be expected, with over a quarter in each of the 30 – 39, 40 – 49 and 50 – 59 brackets, and smaller numbers in the 20 – 29 and 60+ brackets. The vast majority of respondents are on permanent contracts and have over 10 years of teaching experience. Unusually, the proportion of female respondents is higher than that of male, which is not reflective of the population of mathematics lecturers. This is likely due to the fact that the survey was shared on a mailing list of female mathematicians. While it is meaningful to have included the voice of so many female mathematicians here, it must be acknowledged that the results may not be entirely reflective of the full population, given the sample size and the gender skew therein.

**Table 1.** Profile of survey respondents (n=190)

<i>Gender</i>	<i>n</i>	<i>%</i>
Male	87	46%
Female	99	52%
(Blank)	4	2%
<i>Age</i>	<i>n</i>	<i>%</i>
20 – 29	8	4%
30 – 39	52	27%
40 – 49	60	32%
50 – 59	50	26%
60+	19	10%
(Blank)	1	1%
<i>Experience teaching maths in higher education</i>	<i>n</i>	<i>%</i>
0 – 1 year	2	1%
2 – 3 years	11	6%
3 – 5 years	18	10%
5 – 10 years	28	15%
10 – 15 years	39	21%
15 – 20 years	17	9%
20+ years	75	40%
<i>Employment Status</i>	<i>n</i>	<i>%</i>
PhD / Teaching Assistant	2	1%
Short-term contract (<=1 yr)	4	2%
Long-term contract (>1 yr)	22	12%
Permanent	162	85%

The country in which respondents were working at the time of the survey is shown in Table 2. Over a third of respondents were based in Ireland, as are the authors of this work, with all but a tiny proportion of the others based in Europe. Again, while this provides an interesting insight into the spread of experiences across the continent, it cannot be presumed that the results would necessarily generalise beyond that.

Three-fifths of respondents were teaching students who were undertaking a mathematics major, while half of respondents lectured students taking non-specialist (service) mathematics. In terms of class size, 58% had small classes of less than 30 students; 57% had medium-sized classes of between 30 and 100 students; and 37% had large classes of over 100 students.

**Table 2.** Country in which respondents (n=190) were working at time of survey

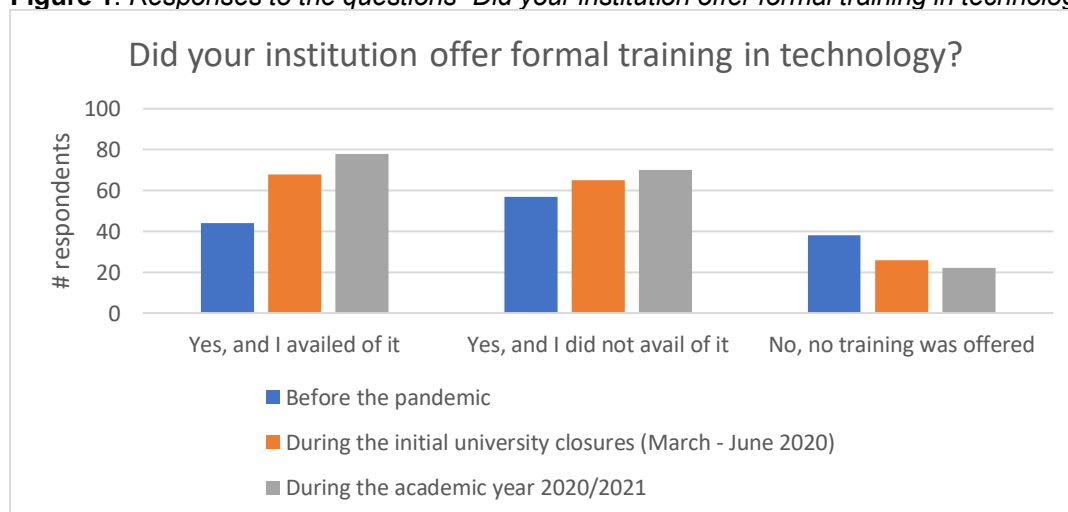
Country	N	%
Ireland	69	36.3%
UK	20	10.5%
France	16	8.4%
Italy	12	6.3%
Germany	9	4.7%
USA	6	3.2%
England / Iceland / The Netherlands	5	2.6%
Scotland	4	2.1%
Croatia / Romania / Switzerland	3	1.6%
Portugal / Sweden / Wales	2	1.1%
Argentina / Austria / Australia / Denmark / Finland / Kuwait / Macedonia / Malta / Nigeria / Poland / Spain / UAE / Unknown	1	0.5%

In the academic year 2020/2021, almost three-quarters of respondents did all of their teaching online, with a further 17% stating it was almost all online. 85% of respondents worked always or mostly from home during that time period. Prior to the pandemic, 75% of respondents had done no online teaching of any kind, with a further 13% having done only a little.

### Reflections on Online Teaching

Before delving into respondents’ experiences of online teaching, we first explored the training they had received in their university, to ascertain the extent and effectiveness of this. Unless stated otherwise, the data refer to the May 2021 survey data only. We therefore asked if respondents had received formal training in technology, and if so, when this was available. The results are shown in Figure 1 below. The vast majority of respondents were offered some kind of formal training by their universities, both during the initial university closures and during the academic year 2020/2021.

**Figure 1.** Responses to the questions “Did your institution offer formal training in technology?” (n=190)



The most common feedback overall about the training on offer was that it was too general and not specific to the teaching of mathematics online (e.g. “*Training tends to ignore specialist software for maths teaching and the focus for other application tends to be not applicable for maths*”). The most common theme from those who availed of training was that it was of use to them (e.g. “*generally helpful, with support for subsequent questions / problems*”). Those who

did not avail of training mostly commented that they either did not need it (e.g. *“I really didn’t need it as am fairly computer savvy”*), were too busy to avail of it (e.g. *“We were getting so many emails about online courses in IT training, it was overwhelming to be honest. I was so busy I just didn’t have time.”*) or that they preferred to ask colleagues for help instead (e.g. *“It was of no interest to me - talking to colleagues was a lot more useful”*).

To explore mathematics lecturers’ experiences of online teaching, we asked a series of questions, where respondents had to rank various reactions to online teaching on a 5-point Likert scale. We first did this in May 2020, and the results are reported in Authors A&B (2021b). We repeated the same series of questions in our May 2021 survey, and the results are shown below.

**Figure 2.** Responses to the questions *“How did you find online teaching when you first began?”* (n=190) and *“How do you find online teaching now?”* (n=190)

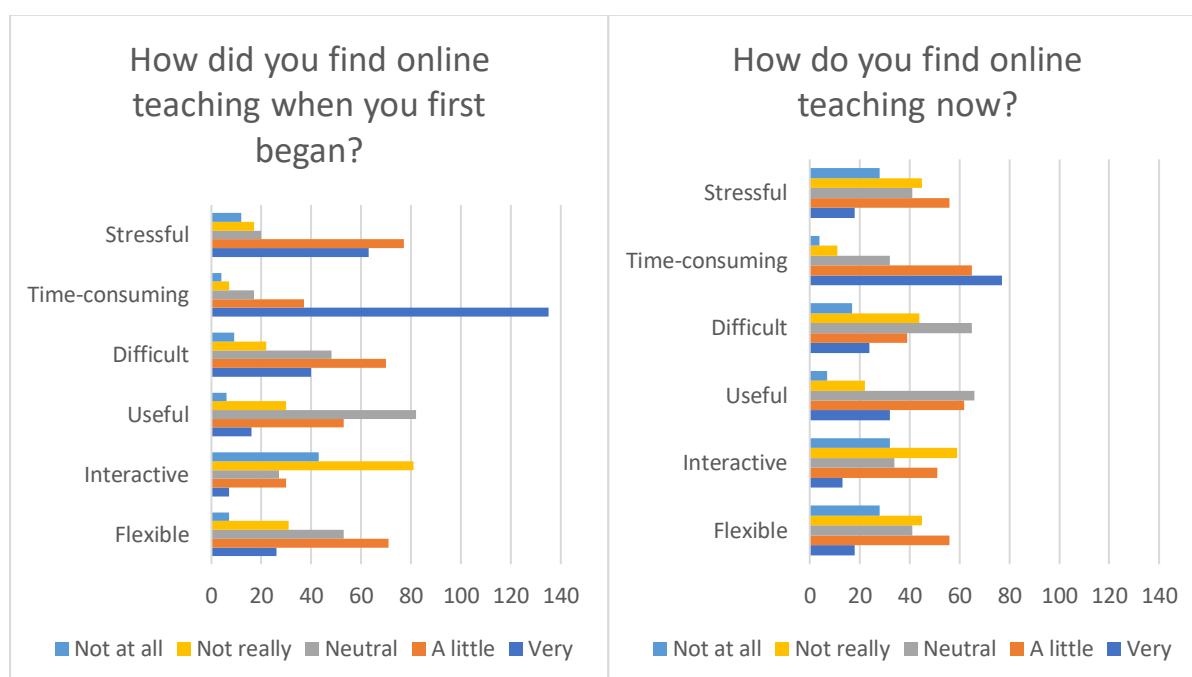
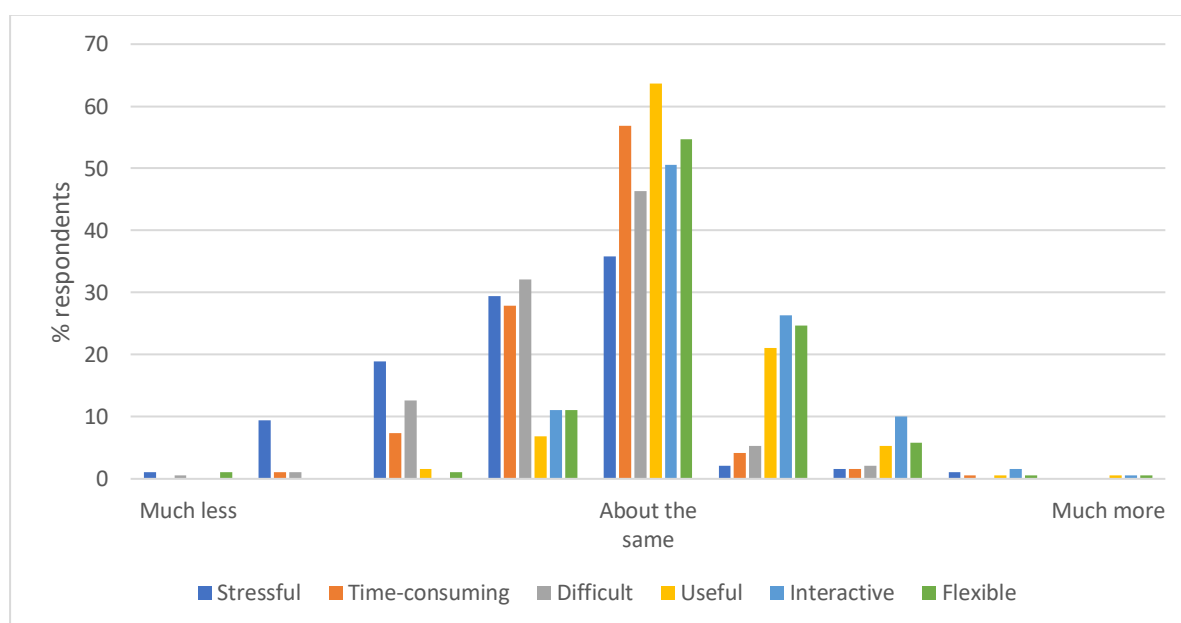


Figure 2 shows how respondents ranked online teaching, both when they first began and in May 2021. The time-consuming nature of online teaching was the most striking element to emerge, with 85% of respondents ranking it “very” or “a little” time-consuming; and although this had reduced after more than a year, it was still the most prominent response with three-quarters ranking it “very” or “a little” time-consuming at this point. 85% of respondents also found online teaching “very” or “a little” stressful when they first began, and similarly, this had only reduced to 75% by May 2021. In our previous survey in May 2020, the corresponding figures were 88% dropping to 79%. The two samples cannot be directly compared as we cannot identify the respondents in each, but the general trend can be observed, whereby there was some small reduction in the perception of the time-consuming and stressful nature of online teaching, but not a lot. It would appear that lecturers found it easier to teach online as their experience grew, as 58% found it “a little” or “very” difficult initially, which dropped to 33% by the end of the academic year. On a more positive note, lecturers’ perceptions of the flexibility of online teaching increased from 51% finding it “a little” or “very” flexible initially to 62% by May 2021. Similarly, their reporting of the usefulness of online teaching increased from 36% initially in the “a little” or “very” categories to 49% a year later. Despite less than a

fifth (19%) of respondents finding online teaching interactive initially, this increased to a third of respondents in the end.

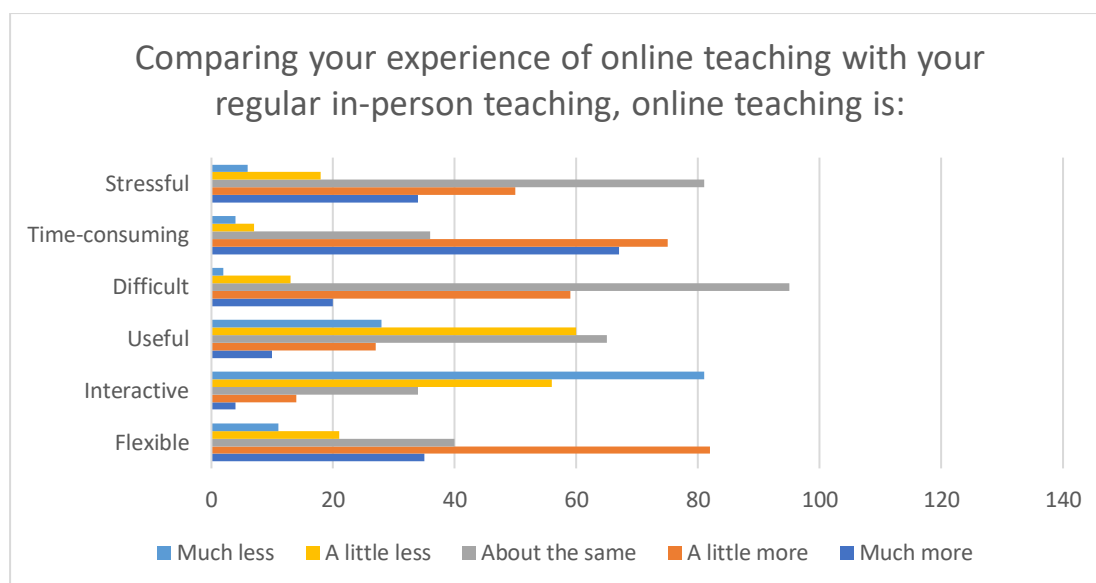
We then investigated the changes in each category for each individual respondent, by comparing their responses to each of the “initial” and “now” questions. The results are shown in Figure 3. We see that the majority of respondents did not change their opinions as time went on, particularly in relation to the usefulness and time-consuming nature of online teaching. However, the stress and difficulty levels are seen to decrease. These responses mirror those of respondents in May 2020 (Authors A&B, 2021b) where a similar pattern was observed. Most respondents, if they did change their opinion, moved only one position in the Likert scale, so very few dramatic changes in their reactions to online teaching were reported.

**Figure 3.** Differences between individual respondents' initial experiences of online teaching versus their experiences more than one year on (n=190)



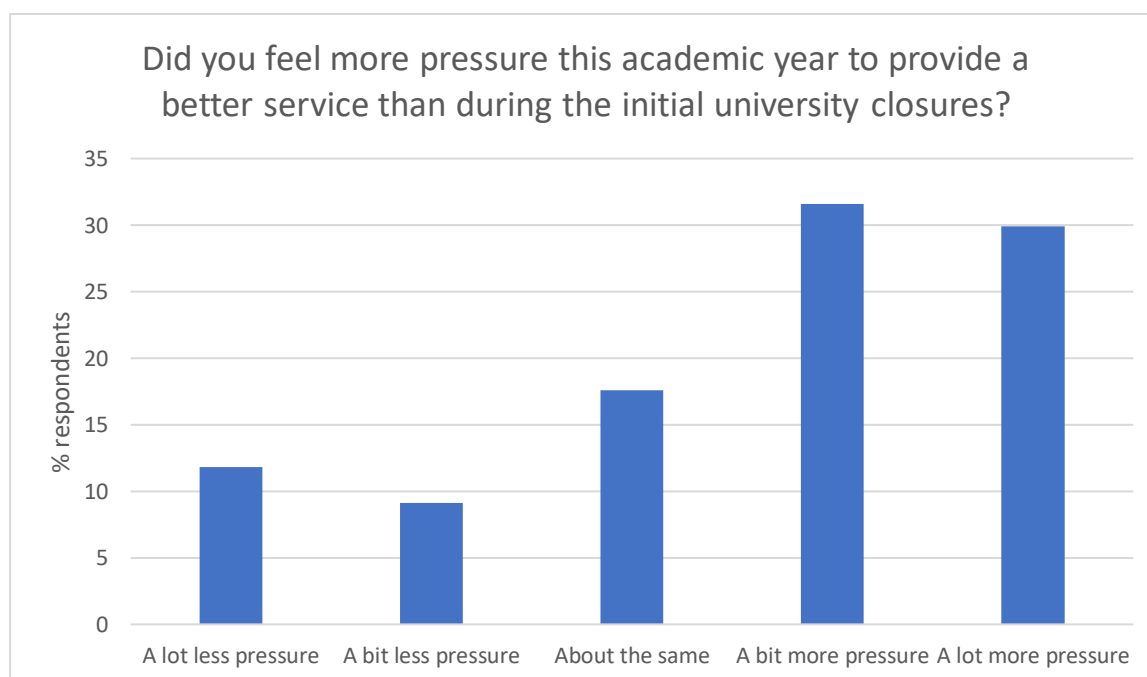
In order to establish how the respondents found online teaching in comparison to their regular in-person teaching, we asked the same series of questions as before (shown in Figure 4), and it emerged that online teaching was considered to be much less interactive but a little more flexible than in-person teaching. If we again compare these results with those of the survey conducted one year earlier (Authors A&B, 2021b), we see that 9% of respondents in 2021 scored online teaching as a little or much more interactive than in-person, compared with 6% in 2020, suggesting little real change. Similarly, 61% of respondents in 2021 thought online teaching was a little or much more flexible than in-person, whereas 57% reported this in 2020.

**Figure 4.** Responses to the question “Comparing your experience of online teaching with your regular in-person teaching, online teaching is:” (n=190)



When asked if they shared teaching tips and support with colleagues more than usual during the academic year 2020/2021, 64% of respondents said that they did a bit or a lot more – just one percentage point less than the previous year’s survey. So although lecturers were further into their journey of remote teaching, the increased engagement with colleagues in terms of discussing teaching approaches and techniques seems to have remained constant.

**Figure 5.** Responses to the question “Did you feel more pressure this academic year to provide a better service than during the initial university closures?” (n=187)



Respondents were then asked if they felt more pressure during the academic year 2020/2021 to provide a better service than during the initial university closures of March 2020, and over 60% of respondents agreed that they did, as shown in Figure 5. When asked for the source of this pressure, three main themes emerged with almost equal frequency: themselves, students and their university. Many respondents in the first category referenced their desire to do their very best (e.g. “Myself most likely - I like to do the best job I can always and I really want my students to enjoy maths”) and also their recognition that this was going to be for a longer time



period (e.g. *“During the initial closures, what we provided felt very ‘scrambled together at the last minute’ -- it was very much emergency online teaching. I did put pressure on myself to ensure that if online teaching was going to last for a longer period of time, the quality should be at a standard comparable to in-person teaching”*). Those who mentioned students as a source of pressure referred to a range of factors, such as the impact of fees (e.g. *“Students even more vociferous about value for money”*), higher expectations (e.g. *“Students might expect more since we had more time to prepare”*) and retention/engagement issues (e.g. *“The fear of losing the disgruntled/disinterested student”*). Finally, those who felt pressure from their university to provide a better service largely felt that decisions were made without consultation (e.g. *“Frankly unrealistic decisions made without consultation by the University management.”*).

## Discussion and Conclusions

The first research question we wished to address was in relation to how mathematics lecturers described their experience of online teaching by May 2021. Although lecturers had somewhat more time to prepare for this academic year of online teaching, it has been observed that advice about teaching mathematics online is still somewhat limited (Quinn et al., 2015). This was reinforced by many of our respondents reporting that there was no discipline-specific training provided by their university for teaching mathematics online. This is disappointing, given that effective training and support is vital in order to ensure proper engagement from lecturing staff when moving to fully online teaching (Jääskelä et al., 2017). Teaching mathematics online has been recognised as having a particularly steep learning curve due to the need for discipline-specific software to handle mathematical symbols (Smith et al., 2008). Lecturers also reported finding online teaching to be time-consuming and stressful, even by the end of the academic year 2020/2021, although they felt the difficulty levels had decreased as they became more used to the techniques involved. However, it should also be remembered that, in most cases, lecturers were faced with having to create online content for a full academic year, having only previously produced material for the final weeks of the year in early 2020, and the time-consuming nature of moving teaching online has long been established (Youngblood et al., 2001).

Our second research question involved exploring any possible evidence of a shift in lecturers' reported experiences of online teaching between May 2020 and May 2021, based on the two surveys issued one year apart. Overall, the results were strikingly similar between the two surveys, with lecturers still reporting similar reactions to and experiences of online teaching, despite the passage of time. As noted above, this could be due to the fact that this was still the first full academic year of online teaching, so there was a considerable workload attached to this, and many were trialling new approaches to keep students engaged with material. One area where they reported a difference was in feeling increased pressure to provide an improved service in the academic year of 2020/2021. This echoes the findings of Plummer et al. (2021), who found that lecturers in physical therapy who were *“accustomed to serving as high-functioning classroom authorities, now felt pressure to advance their novice skills as online educators to expert levels in a short period.”* Given the reported levels of stress relating to online teaching, and this increased pressure to perform at a higher level, there is an obvious danger of burnout among academics in this position, as identified also by VanLeeuwen et al. (2021), who suggested a range of measures to counteract this. However, it was promising to observe that the reported increase in engagement with colleagues on teaching matters has also not changed one year on, suggesting a real opportunity for increased open discussion on pedagogy matters in mathematics in higher education among faculty members who might not have done so prior to the pandemic. It would be advisable to universities to capitalise on this



by providing discipline-specific pedagogical training in mathematics, both for online and in-person teaching, in order to enhance the teaching and learning of mathematics in higher education by building upon the lessons learned through emergency remote and online teaching during the pandemic.

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