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RESEARCH ARTICLE

The impact of remote teaching on statistics learning and anxiety

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Abstract

In March 2020, staff and students at UK universities had to suddenly transition from on-campus teaching to remote learning as a result of the pandemic, which continued throughout the 2020/21 academic year. Unlike traditional online learners, students may lack the motivation or confidence to learn as effectively online particularly for modules such as statistics which students often find difficult or stressful face to face.

This paper uses survey results from students studying elective and compulsory statistics modules in the 2020/21 academic year to gain an insight into remote learning of statistics from the students' perspective.

When compared to previous face to face teaching of statistics, students were less likely to actively engage with material, ask for help or work with peers remotely. Emotional wellbeing, motivation to learn, statistics anxiety and having a suitable learning environment all impacted on being able to learn statistics remotely. Although statistics anxiety in online teaching situations was generally lower, there was no evidence to suggest anxious students would benefit from online learning going forward.

Keywords: statistics anxiety, motivation, remote learning.

1. Introduction

The term 'online learning' refers to courses which are delivered in a fully virtual environment relying on the use of the internet for teaching material and interactions with teaching staff and other learners. Studies into online learning often look at the attributes of a successful e-learner (Wighting, Liu and Rovai, 2008) with motivation (Horzum et al, 2015) and engagement (Martin and Bolliger, 2018) being key factors of both retention and success. Motivation was described as the 'engine' of learning by Paris and Turner (1994), highlighting its importance in effectively undertaking learning of any kind. Intrinsic motivation, where students are innately interested in the topic and see value in learning it, is particularly important (Pintrich et al, 1991) and has been shown to relate to both performance and statistics anxiety (Marshall et al, 2021). When a student is motivated by the desire to perform well this is known as extrinsic motivation.

Whilst research suggests that online learners generally have higher intrinsic motivation (Schroff et al, 2007), Park and Choi (2009) found that online courses had higher drop-out rates compared to face-to-face courses of a similar nature. Key factors for high drop-out rates in online courses include lack of motivation (Artino, 2008; Keller, 2008), technology issues (Hara & Kling, 2003), feelings of isolation

and loneliness (Paulus & Scherff, 2008), and problems with time due to external responsibilities (Keller, 1999).

Hodges et al. (2020) suggest that it typically takes six to nine months to plan, prepare and develop a fully online university course, but in Spring 2020 both staff and students had to transition almost overnight from on-campus teaching to enforced remote learning. Most academic staff lacked the pedagogical or technological experience to adapt quickly to online delivery and many students lacked 'online readiness', which includes a lack of suitable technology or learning environment at home (Horzum et al, 2015; Hung, 2010; Hodges et al., 2020; Ching et al., 2018).

Statistics anxiety is the worry felt by an individual towards statistics in any form and at any level and is thought to 75%-90% of students (Onwuegbuzie & Wilson, 2003; Marshall et al, 2021). Students often have negative attitudes as well as anxiety towards statistics (Sese et al, 2015) which impact on self-efficacy (Finney & Schraw, 2003), motivation and perseverance. Whilst there is very little literature on statistics anxiety and online learning, Devaney (2010) found that the online students had suffered from higher levels of statistics anxiety compared to their on-campus counterparts.

This paper uses survey data collected from students studying both compulsory and elective statistics modules during 2020/21 to get an overview of the students' experiences of remote learning, investigate the factors impacting most on being able to learn remotely and whether learning online may benefit or hinder students with statistics anxiety.

2. Methods and cohort differences

Two separate online surveys were carried out at the start and end of the academic year 2020-21 for specific cohorts studying statistics at Sheffield Hallam and the University of Glasgow although apart from the section on statistics anxiety, this paper focuses on the results from the second survey from Spring 2021.

Most questions used were 7-point Likert and scale means were calculated to represent key academic factors which are described within the relevant sections of the results as well as the Appendix (with Cronbach's alpha scores). A key scale used throughout is students' perception of their ability to learn remotely was assessed using three questions: whether they felt able to learn statistics remotely, software remotely and complete assessments to a good standard. The Motivated Strategies for Learning Questionnaire (Pintrich et al, 1991) was used to measure motivation, asking students or staff for help when needed and task value (intrinsic motivation).

Table 1. Students participating in the two surveys.

Institution	Survey taken	1st year	2nd/final year
<u>University of Glasgow</u>	October 2020	90	
	Feb/March 2021	44	22
<u>Sheffield Hallam University</u>	October 2020	151	
	April-July 2021	54	33

Although the focus of the paper is not an evaluation of teaching methods, a brief overview of the cohorts taking part in the study at Sheffield Hallam and Glasgow Universities and teaching delivery in 2020/21 is given here.

The first-year statistics modules at the University of Glasgow are elective whereas statistics is compulsory for first- and second-year Mathematics and Psychology students at Sheffield Hallam. At Glasgow, the first-year modules are open to students from any program of study conditional on sufficient grades in mathematics at school and the second-year modules are open to students with sufficient first year maths grades.

In Glasgow the first-year students had assigned reading and online exercises in preparation for online live interactive lectures which were recorded and made available to those who could not attend. All Sheffield Hallam and second year Glasgow students predominantly had asynchronous recorded lectures to accompany the lecture notes followed by live online tutorials although Psychology students also had a few face-to-face tutorials at the start of the year. Sheffield Hallam Mathematics and Psychology students both have some form of peer support within their first year to encourage communication between students and staff.

3. Results

3.1 Learning statistics remotely, engagement and motivation

Independent t-tests were used to test for cohort differences. As the boxplots in Figure 1 show, there were some noticeable differences between the students studying elective and compulsory statistics modules with Glasgow students significantly more likely to feel they were able to learn remotely ($p < 0.001$, MD=1.2) but less likely to ask for help ($p < 0.001$, MD=1.1). The mean differences between cohorts were much larger when comparing first year students and although not significant, first year students felt less able to learn remotely than second years.

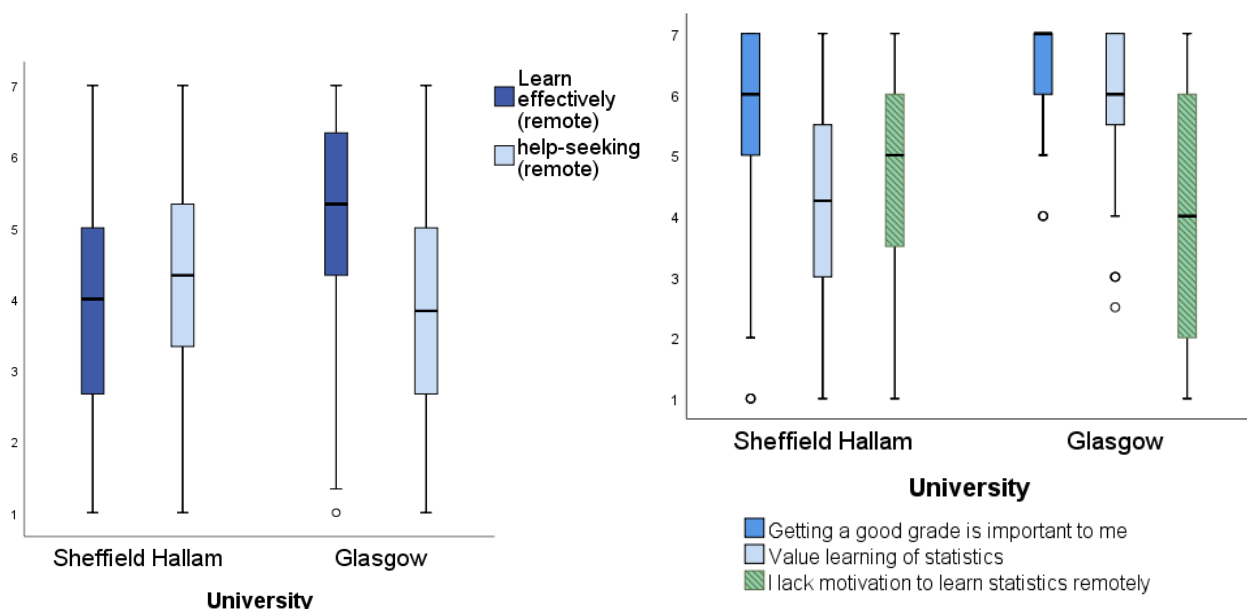


Figure 1. 'Boxplots of being able to learn remotely, motivation and helpseeking'.

Glasgow students were also more motivated by a desire to do well ($p < 0.001$, $MD = 0.74$), more intrinsically motivated ($p < 0.001$, $MD = 1.8$) and are less likely to lack motivation to study statistics ($p = 0.005$, $MD = -1$) which given they are studying an elective course is not surprising.

Passive learning was classified as basic engagement with a course such as attendance and watching videos whereas the active engagement scale asked about engaging more with material or others (see Appendix). Sheffield Hallam students' average levels of passive engagement were significantly lower than Glasgow ($p < 0.001$, $MD = -1.3$) where most students were passively engaging. Active engagement was lower but similar for the two groups. Research suggests that students may perceive passive learning as more useful than active learning (Deslauriers et al, 2019) and if extrinsically motivated, may regard focusing on what they need for assessment with more control over how and when they learn. 64% of Sheffield Hallam students and 73% of Glasgow students agreed that they focused on studying what they needed for assessment when studying remotely.

Students were also asked whether they thought lectures and videos were effective for learning statistics and although 45% and 65% of Sheffield Hallam and Glasgow students felt videos were at least somewhat effective, only 18% and 23% respectively thought they were more effective than on-campus lectures. Further results for Sheffield Hallam showed that 76% of students would prefer videos to be a back up rather than the main source of learning but 45% said they would be less likely to attend if recorded back up was available.

3.2 Comparison with on campus delivery

Students who had experienced learning statistics pre-pandemic were also asked the same questions about learning statistics on campus. An interesting and significant interaction between institution and mode of delivery was observed through a mixed ANOVA, $F(1,40) = 5.2$, $p = 0.028$. As Figure 2 shows, there was no significant difference between cohorts when learning on campus but a substantial difference when learning remotely. For Sheffield Hallam students, there was also a significantly higher mean for learning on campus compared to learning remotely ($p = 0.014$).

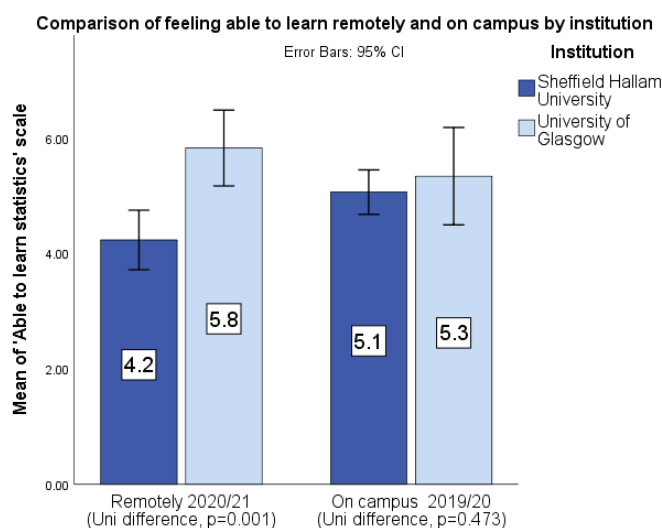


Figure 2. Remote and on-campus differences for being able to learn.

Figure 3 shows the mean paired differences (remote – on-campus), confidence intervals and paired t-test results for other key aspects of learning. Apart from an increased use of the internet, most aspects

of learning were worse remotely with active engagement, working with other students and asking for help significantly lower when learning remotely. Sheffield Hallam students had significant differences for all aspects except using the internet more which was significantly higher only for Glasgow students.

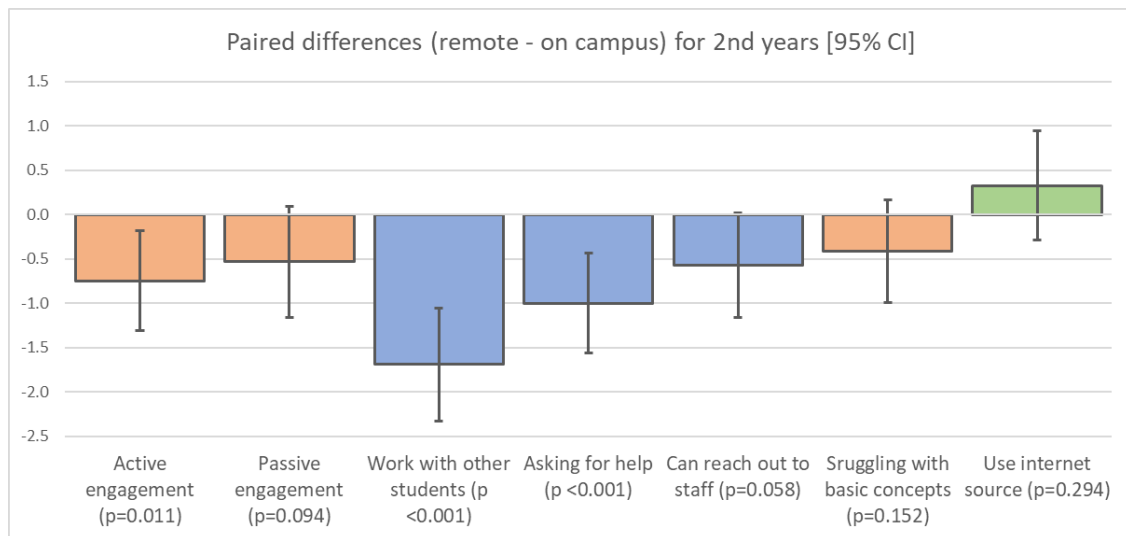


Figure 3: 'Paired mean differences (remote – on-campus) and t-test results for 2nd years'.

3.3 Online readiness and emotional well-being

It was anticipated that the impact of living through a pandemic, even apart from the move to online learning, may impact negatively on emotional wellbeing. Students were asked how often they felt sad, emotionally exhausted, worn out and had problems concentrating in the past few weeks on a Likert scale ranging from Not at all (1) to All of the time (5).

Worryingly, at the time of taking the survey 83% of Sheffield Hallam students and 59% of Glasgow students had a mean score of at least 3, suggesting that the majority of students were struggling with negative emotional wellbeing at least a part of the time. An independent t-test showed that Sheffield Hallam students had significantly higher levels of negative emotional wellbeing ($t(146) = 3.21$, $p = 0.002$, M.D. = 0.5) than students at the University of Glasgow.

Another aspect explored related to the 'online readiness' of students studying remotely. Even though students had been learning remotely for quite a while by the time of the survey, many still did not have a suitable place to study, had technology issues making it difficult to study online, or felt unable to manage their workload online, particularly at Sheffield Hallam (see Figure 4). These issues are likely to impact on learning, stress and motivation and represent an increased risk of falling behind.

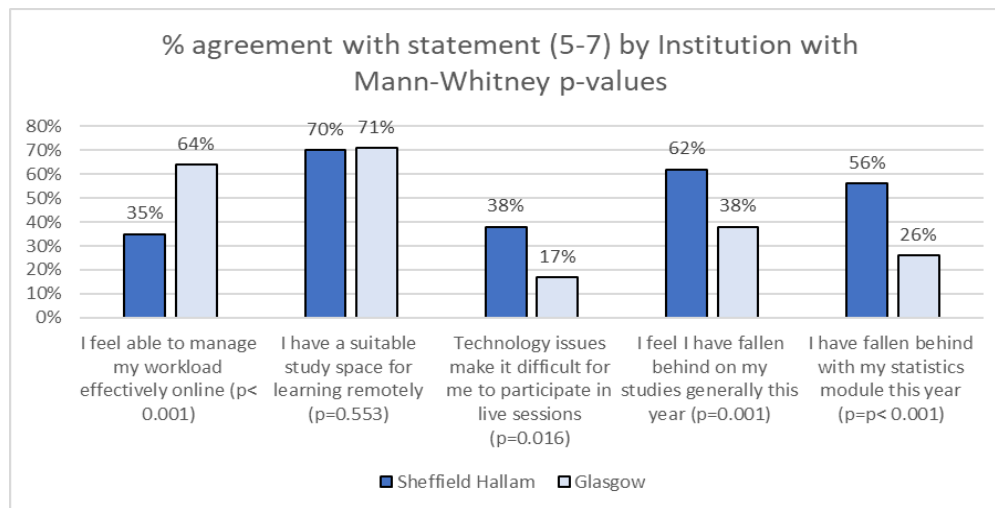


Figure 4. Summary of online readiness and falling behind responses by cohort.

While it was anticipated that students would particularly struggle with statistics following the move to online teaching, this does not seem to be the case. Fewer students reported falling behind with statistics than falling behind with their studies in general.

3.4 Factors impacting on learning remotely

Figure 5 summarises relationships between students' feeling that they can learn remotely and other factors such as motivation, emotional well-being and online readiness to study. Pearson's correlations (r) are given for individual aspects, R^2 for block contribution to explained variance of being able to learn and significant predictors from a final backwards regression model (explaining 60% of the variation in being able to learn) are starred.

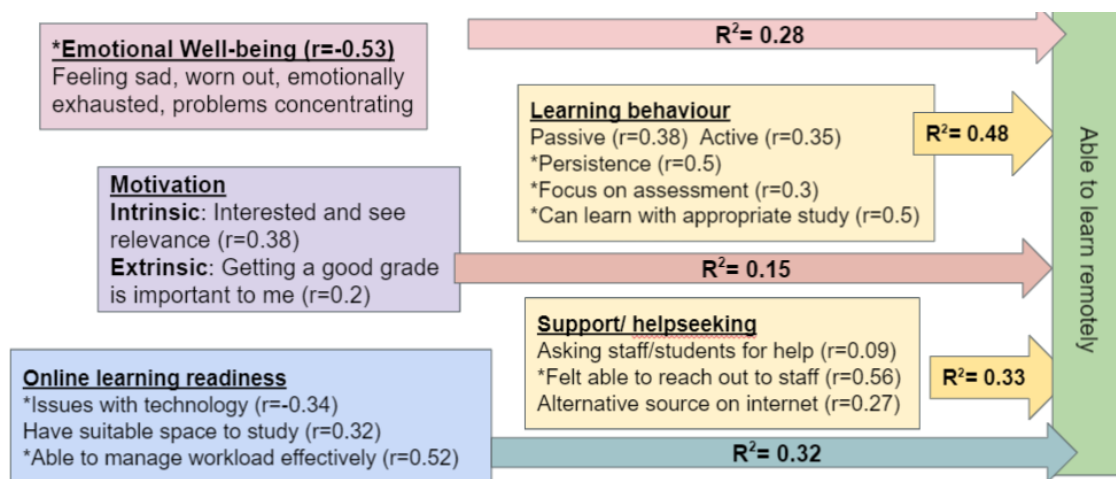


Figure 5. relationships with 'able to learn remotely'.

Negative emotional wellbeing was a strong negative predictor of feeling able to learn remotely and students' motivation (particularly intrinsic) had a moderate positive impact. Online readiness explained 32% of the variation in being able to learn with reported ability to manage workload the strongest predictor.

Regarding learning behaviour and help-seeking, the strongest positive predictors were belief they can learn statistics if they study appropriately (control of learning), persistence and feeling able to reach out to staff if struggling. Students who focused on assessment were more likely to feel they were able to learn remotely but this may not be reflected in their understanding of the topic or final grade. There was no significant difference in feeling able to learn between the two institutions after controlling for motivation and negative wellbeing and learning behaviour. These results suggest that students on elective courses are more motivated to learn which leads to better engagement and learning outcomes.

Statistics anxiety was measured using the Statistical anxiety measure (SAM; Earp, 2007) which gives a general measure of statistics anxiety and the help-seeking anxiety subscale from the Statistics anxiety rating scale (STARS; Cruise, Cash and Bolton, 1985). In addition, subscales relating specifically to online and on-campus situations and software were created (see Appendix). Students were asked how anxious they felt in a variety of situations from 1 (Not at all anxious) to 7 (Extremely anxious) for all subscale items.

All students taking the October survey were asked these questions including the first-year cohort from Glasgow who later took part in the second study. Although some students took both surveys, the results in Table 2 are not paired due to small numbers.

Table 2: Comparison of mean scores at the start and end of the year

Survey details				Type of statistics anxiety							Other factors			
Survey	Institution	Year Group	N	Task	Software	Help seeking	Online class	Face to face class	Watching videos	Working with students online	Working with students face to	Getting help when needed	I lack motivation to learn statistics	Task value
Start of year	Sheffield Hallam	1	151	4.3	4.2	3.5	2.7	3.5	1.9	3.4	3.4	5.0	3.5	4.7
	Glasgow	1	90	3.6	3.6	3.8	2.8	3.4				4.2	2.7	5.8
End of year	Sheffield Hallam	1	54	5.0	4.6	4.6	4.1	4.6	3.0	4.4	4.5	4.3	4.9	4.0
	Glasgow	1	44									3.1	3.6	6.0
	Sheffield Hallam	2	33	4.9	4.3	4	3.7	3.1	3.2			4.4	4.4	4.4

At the start of the year, class anxiety in an online setting was significantly lower than perceived anxiety in a class on-campus with watching recorded content having a very low mean value. Despite choosing to study statistics, some students at Glasgow do experience anxiety about statistics particularly around help-seeking which is significantly higher than at Sheffield Hallam ($p=0.006$). This higher level of anxiety about seeking help may help explain why Glasgow students were less likely to ask for help and more likely to use the internet as a source compared to Hallam students.

By the time of the second survey, the means for the first-year students had increased particularly in an online situation. For second year students who experienced both face to face and online learning actually feel less anxious about face-to-face teaching than they are about online. Students were less likely to ask for help or value the learning of statistics and more likely to lack motivation at the end of the year.

Further investigation of relationships between emotional wellbeing, intrinsic motivation, and statistics anxiety with key learning behaviours and opinions on the use of videos for teaching statistics are contained in Table 3. Partial correlations, controlling for emotional wellbeing, were used for statistics

anxiety to separate statistics anxiety from emotional wellbeing as emotional wellbeing was related to help-seeking anxiety in particular and was likely to be increased due to the pandemic.

Negative emotional wellbeing and general lack of motivation to learn statistics are generally the strongest predictors but intrinsic motivation has a bigger impact on a student's belief that they can learn statistics if they study effectively (control of learning) and how effective they think videos are for learning statistics. Even after controlling for emotional wellbeing, students anxious about statistics are less likely to feel they can learn statistics, reach out to staff if struggling, learn statistics remotely or find videos an effective method for learning statistics. These findings and those in Figure 5 suggest that motivation, emotional wellbeing and statistics anxiety are impacting on learning behaviour and beliefs which in turn affect being able to learn effectively remotely and opinions on the effectiveness of videos.

Table 3: Partial stats anxiety correlations after controlling for emotional wellbeing

Cohort	All students			Sheffield Hallam students only			
Statistic	Pearson's correlations			Partial correlations (controlling for emotional wellbeing)			
Factor	Negative emotional well being	Lack motivation to learn	Intrinsic motivation	Statistics task anxiety (SAM)	Software anxiety	Help seeking anxiety (STARS)	Class anxiety (online)
Negative emotional well being		0.46	-0.27	0.31	0.24	0.49	0.37
Lack motivation to learn statistics			-0.3	0.30	0.14	0.25	0.33
Intrinsic motivation (task value)				-0.31	-0.27	-0.19	-0.35
Able to learn remotely	-0.53	-0.47	0.38	-0.51	-0.49	-0.46	-0.40
Videos are effective for learning statistics	-0.29	-0.33	0.37	-0.25	-0.31	-0.27	-0.31
Effectiveness difference (video - lecture)	-0.25	-0.21	0.19	-0.06	-0.07	-0.13	-0.15
Able to manage workload effectively	-0.55	-0.5	0.24	0.08	0.05	-0.08	-0.06
Control of learning	-0.32	-0.3	0.51	-0.41	-0.34	-0.32	-0.41
Persistence	-0.32	-0.62	0.26	-0.13	-0.10	-0.19	-0.18
Can reach out to staff if needed	-0.39	-0.31	0.31	-0.24	-0.31	-0.36	-0.39

4. Conclusions and discussion

This study has given an overview of the student experience of learning statistics remotely during a pandemic for elective and compulsory cohorts. Many students experienced problems with emotional wellbeing, their study environment or motivation which impacted on learning. Although some students felt able to learn online and thought videos were an effective method of learning, the majority thought lectures were more effective than videos for learning and would prefer recorded content to be a back up. When compared to experiences on campus prior to the pandemic, students were much less likely to actively engage with learning material, work with other students or seek help when needed with students on compulsory statistics modules being more affected by the switch to remote learning.

In line with previous literature on students studying online by choice, this study has shown that motivation, online readiness and engagement are key predictors of being able to learn remotely. In addition, negative emotional wellbeing and statistics anxiety have a negative impact on learning behaviour, motivation, opinion on the effectiveness of videos and being able to learn remotely. Students studying elective statistics modules felt more able to learn but this difference was explained most by a higher level of intrinsic motivation impacting positively on learning behaviour.

Students surveyed at the start of the year generally felt less anxious in online situations but average statistics anxiety increased and the gap was reduced by the end of the year. For second years who had also been taught statistics face to face, anxiety in online settings was actually higher which is more consistent with Devaney (2010).

Looking forward to future education of statistics, some online learning could be considered for elective cohorts, who have suitable environments to learn remotely and are motivated to learn independently but has been detrimental to those with negative emotional being, statistics anxiety or lacking motivation so is not generally recommended for teaching statistics. Further research could investigate when and how to use recorded content effectively particularly regarding anxious students and why students at Glasgow are less likely to seek help.

5. Acknowledgements

The data collection had ethical approval from Sheffield Hallam and University of Glasgow.

6. Appendix

The following questions were contained in the scales used in the survey for the end of the academic year at Sheffield Hallam and Glasgow Universities. They are grouped by subscale where appropriate with Cronbach's alpha. Most questions were taken directly or adapted from the Motivated Learning Strategies Questionnaire.

Scale	Engagement with statistics learning activities remotely (7 point SD - SA)
Passive engagement (Cronbach's alpha = 0.88)	I generally attended live teaching sessions online
	I regularly watched all recorded content
	I generally attended online statistics tutorials
Active learning (Cronbach's alpha = 0.88)	I regularly attempt the weekly exercises or tasks associated with learning content
	I actively participate in learning in live online sessions e.g. take notes, complete exercises/tasks, communicate with others
	I actively participate in online tutorials e.g. complete exercises/tasks, communicating with staff/students about class work
Learn effectively remotely (Cronbach's alpha = 0.85)	I am able to learn statistical software effectively remotely
	I am able to learn statistics material effectively remotely
	I feel able to complete any assessments to a good standard this year
MLSQ: Help-seeking (Cronbach's alpha = 0.64)	If I don't understand something, I ask a member of staff for help
	If I don't understand something, I ask another student for help
MSLQ: Effort regulation/ Persistence (Cronbach's alpha = 0.57)	I work hard in my statistics module even if I didn't like what we are doing
	When coursework is difficult, I give up or only complete the easy parts (REVERSED)
Single questions using same 7-point strongly disagree - agree	
I focus on studying what I need for assessment when learning remotely	
I lack motivation to learn or continue learning statistics remotely	
If I don't understand something, I search for an alternative source on the internet	
I felt I could reach out to statistics staff if I was struggling	

Second year students were asked all of the above questions again but for last year when they had face to face classes for most of the year.

The questions for the 'emotional wellbeing' scale were taken from the from the English version of the Third Copenhagen Psychosocial Risk Assessment Questionnaire (COPSOQIII)

Negative wellbeing (Cronbach's alpha = 0.9)	Thinking generally about how you have been feeling over the past month, how often have you: 1=Not at all; 2=A small part of the time; 3=Part of the time; 4= A large part of the time; 5=All of the time
	Felt worn out
	Emotionally exhausted
	Had problems concentrating
	Felt sad

Statistics anxiety was measured using the Statistical anxiety measure (SAM; Earp, 2007) which gives a general measure of statistics anxiety and the help-seeking anxiety subscale from the Statistics anxiety rating scale (STARS; Cruise, Cash and Bolton, 1985). In addition, subscales relating specifically to online and on-campus situations and software were created. Students were asked how anxious they felt in a variety of situations from 1 (Not at all anxious) to 7 (Extremely anxious) for all subscale items. The items used for each statistics anxiety subscale are given below with Cronbach's alpha.

Subscale	Individual items
Online class anxiety (CA=0.9)	Attending an online statistics lecture
	Attending an online statistics tutorial
Face to face class anxiety (CA=0.9)	Being in a statistics lecture in person on campus
	Attending a statistics tutorial in person on campus
Statistical anxiety measure (CA=0.95)	Sitting an exam in person on campus
	Studying statistics generally
	Reading statistical studies
	Calculating probabilities
	Formulating and testing hypotheses
	Developing conclusions based on mathematical solutions
	Interpreting statistics
Software anxiety (CA=0.93)	Explaining your statistical findings
	Inputting/manipulating data in statistical software
	Using statistical software to carry out analyses
Help-seeking anxiety (CA=0.91)	Summarising results from the statistical software output
	Going to my statistics lecturer for individual help with material I am having
	Asking a statistics lecturer for help understanding computer output
	Asking a fellow student for help in understanding statistics material

	General preferences for videos (irrelevant of what they had this year)
SHU and Glasgow	Videos are an effective way to learn statistics
	Lectures are an effective way to learn statistics
SHU only	Doing examples is an effective way to learn statistics
	I prefer to learn statistics primarily from recorded content rather than lectures
	I prefer to learn statistical software primarily from recorded content rather than face
	I would like videos to be a back up for missed sessions or for revision purposes
	If I knew lectures were recorded, I would be less likely to attend in person

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