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Can the same statistics module be used for service teaching by tailoring the support based on the student's chosen qualification?

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Abstract

At the Open University in the UK, students taking undergraduate degree qualifications in areas such as Data Science and Economics are now the largest cohort of students on a second-year undergraduate statistics module, originally written for specialist mathematics and statistics students. This paper outlines an ongoing project to identify how more targeted support could be provided to students who are studying non-mathematics and statistics qualifications. This has involved engaging all the tutors who provided support in the project to create a new way of adapting their teaching styles and tutorial content. By grouping students who had similar qualification goals together and linking these groups to individual tutors, the new way of working created an atmosphere where students feel able to share their own misunderstandings and see how statistics is useful within their chosen qualifications.

Keywords: Service teaching, student support, action research

1. Introduction

1.1 Teaching statistics to non-mathematics and statistics students

Many university qualifications include a proportion of statistical training for students who are studying non-mathematics and statistics undergraduate degrees. How students are taught statistics can differ depending on the qualification and the university in which they are studying. It can range from a few afternoons of statistical training, modules which focus on statistical learning through to subject-focussed modules with elements of statistical learning embedded within them. It is also the case that many of these students show a lack of confidence about mathematics and statistics which can be problematic for their studies (Hodgen et al, 2014).

At the Open University (OU) many of the statistics modules serve multiple qualifications, with students on a single module studying a wide range of different qualifications. To meet the differing needs of these students the module material is usually written with a range of examples and scenarios to which all students can relate (Hilliam and Vines, 2021). However, there are some modules which are written to serve students on a specific qualification, this was the case for the module *Analysing Data (M248)*; the subject of this case study. This module was written for students studying specialist Mathematics and Statistics (M&S) qualifications. As new qualifications have been developed, one example being the Data Science degree, existing modules have been used to fulfil learning outcomes for these qualifications. Whilst the fundamental statistical methods which students need are the same regardless of their qualification, students are more likely to understand the relevance of the material if it is embedded within their chosen qualification subject area (Mustafa, 1996; Tishkovskaya and Lancaster, 2012 and MacDougall et al, 2020). Of course, due to resourcing

issues it is not always possible to create multiple versions of the same module to be used across multiple different qualifications, and indeed this was not possible for *M248.* Nor was it possible, given resource and time constraints, to re-write the module to include examples specifically chosen to appeal to multiple audiences. Therefore, through the action research outlined in this paper, a different approach has been taken which focussed on providing dedicated qualification-based support for groupings of students on similar qualifications (qualification-based groups).

1.2 Supporting students at the OU

Academic support is provided at the OU by a network of about 6,000 tutors officially designated Associate Lecturers (ALs). Several ALs are contracted to each module and each support a group of students, usually 20, through their study of that individual module. This enables students to engage with distance learning through a combination of high-quality teaching material (both printed and online) and receive correspondence tuition from their designated AL. The ALs provide tutorials (online versions are usually recorded for later viewing), correspondence tuition (via feedback on continuous assessment) and one-to-one academic support via email amd telephone. For historical reasons, mainly to ensure UK wide coverage of face-to-face tutorials, ALs usually support a group of 20 students within a given geographical area. Online tutorials have been provided by these ALs since the early 2000s, and up until March 2020 a combination of face-to-face and online tutorials were provided. The attendance at face-to-face tutorials on M248 had been decreasing prior to March 2020 when the Covid19 pandemic forced all tutorials online. Decreasing the number of face-to-face tutorials and replacing these with online tutorials, meant there were a much larger number of online tutorials which students could attend. This provided an opportunity to think about the best way of using the increased number of online tutorial hours and linking these to specific qualifications. The case study in this paper outlines some of the steps taken to move from geographically based support to a qualification-based support which included a range of different types of online tutorials.

1.3 M248 students

Alongside the lack of attendance at face-to-face tutorials there was a growing realisation that the cohort of students who studied *M248* was changing. Mathematics and statistics modules at the OU are reviewed every year. Whilst the modules are usually refreshed, re-written or replaced every 5-10 years, the content is unlikely to substantially change unless there is a compelling business case to do so. The last re-write of *M248* was completed for students to start studying in Oct 2017. It was expected that the material would remain substantially unchanged for at least 10 years. At that time the module was written primarily for students studying for qualifications in mathematics and statistics with the module split into 13 units:

- Unit 1: Exploring and interpreting data
- Unit 2: Modelling variation
- Unit 3: Models for discrete data
- Unit 4: Population means and variances
- Unit 5: Events occurring at random and population quantiles
- Unit 6: Normal distributions
- Unit 7: Point estimation
- Unit 8: Interval estimation
- Unit 9: Testing hypotheses
- Unit 10: Nonparametric and goodness-of-fit tests
- Unit 11: Regression
- Unit 12: Transformations and the modelling process
- Unit 13: Applications.

Each unit covers about 16-18 hours of student learning which students are expected to complete in roughly 2 weeks. Unit 13 is a consolidation unit and contains no new material. It is assumed that students possess a basic knowledge of calculus and a reasonable level of mathematical maturity with the ability to manipulate mathematical equations, which is true for all students studying M&S qualifications.

Table 1 shows the distribution of which qualifications *M248* students are studying. In Figure 1, to make comparisons easier, the qualifications have been split into four main groups: Mathematics & Statistics (M&S), Economics, Data Science & Computing (Data Science) and Other qualifications and standalone study (Open). In 2017 and 2018 over 45% of students on M248 were studying for M&S qualifications (Table 1 and Figure 1). In addition, there were a reasonable number of students studying various other qualifications including the Open degree (where students can choose any modules to study for their degree providing the total number of credits at each level is satisfied). Students can also study individual modules without linking them to any qualification, known as standalone study, there have always been students who studied OU statistics modules in this way as part of their ongoing continual professional development.
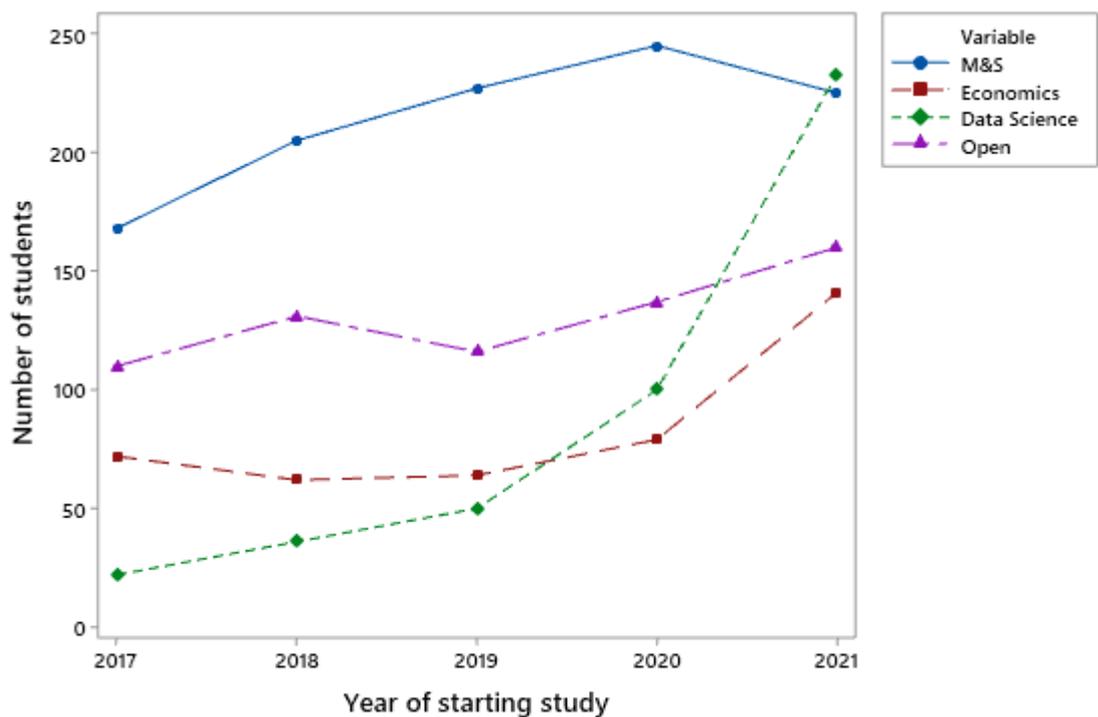

Figure 1. Number of students on qualification types students who have studied M248 between 2017 and 2021.

Qualification-based group	Qualification studied	Year in which study of M248 commenced (Oct)				
		2017	2018	2019	2020	2021
M&S	BSc (Hons) Mathematics	61	111	108	137	113
	BSc (Hons) Mathematics & Statistics	107	94	119	108	112
Economics	BSc (Hons) Economics & mathematical sciences	71	59	53	53	66
	BSc (Hons) Economics	1	3	11	26	75
Data Science	BSc (Hons) Computing & IT with statistics	17	32	32	33	33
	BSc (Hons) Data Science	5	4	18	67	200
Open	Standalone module study	23	31	29	36	30
	BSc (Hons) Open	61	49	38	43	40
	BSc (Hons) Combined STEM	12	28	33	36	45
	Other qualifications	14	23	16	22	45
Total		372	434	457	561	759

Table 1. Distribution of students studying *M248* between 2017 and 2021 split by qualification.

In 2019 two new degrees were introduced at the OU, BSc (Hons) Economics and BSc (Hons) Data Science, both of which include *M248* as a compulsory module. This led to an increase in students on M248 and changed the distribution of the type of student studying on *M248* (Table 1). This change in the student distribution meant that by 2021 *M248* was primarily a service module for non-M&S students, even though the module material was very much written for mathematically competent students.

The increase since 2019 in the non-M&S qualifications can be clearly seen in Figure 1 (note that it is possible for students to retrospectively link a module to a qualification which explains the Data Science and Economics student numbers prior to 2019). These four qualification-based groups formed the basis for deciding how to tailor support for students dependent on their qualification goal. This paper outlines the steps taken in the action research starting in 2018 to address this issue.

2. Methodology

In 2018 it was evident that students on non-M&S qualifications tended to have a lower pass rate than their M&S counterparts. To address this several interventions were put in place over a period of three years. An action research approach was taken. Action research is practitioner research and follows a cyclical pattern of identifying a problem and designing an intervention, acting on the intervention, evaluating the result and then modifying and acting all over again (McNiff and Whitehead, 2005). At each phase of the study different methodology was used to answer the new question or questions generated by the previous phase of the action research. Figure 2 shows the timeline of the project and a summary of the methodology used at each phase. The interventions, evaluations and results for each phase are outlined in Section 3.
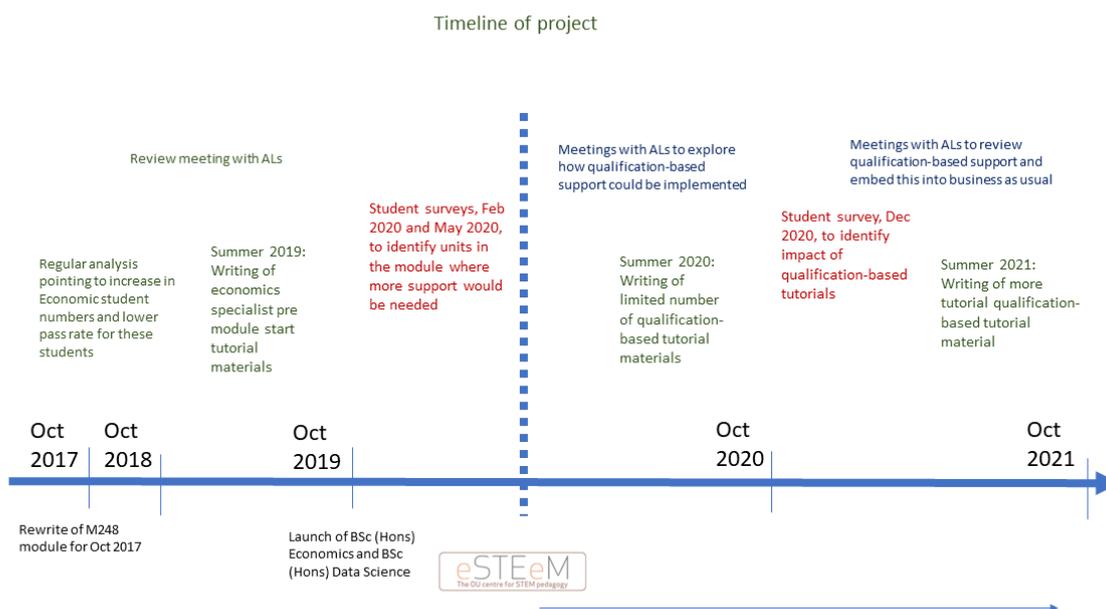

Figure 2. Timeline of the qualification-based support project on M248.

To facilitate the interventions, it was necessary to ensure the ALs were involved in the project. In 2017 there were 18 ALs on *M248* who were essentially recruited with the aim of tutoring M&S students. By 2021 this had grown to 40 ALs and because of this project some of ALs were recruited specifically to tutor explicit groups of non-M&S students. The transformation in focus for these ALs has been considerable and a large amount of work has gone into ensuring this change has been a team effort. The first stage was to ensure the ALs understood the reason change was needed, initially due to the differential pass rate and later due to the large increase of non-M&S students. März and Ketch (2003) highlight the need for an individual to understand the problem and the social process needed for the acceptance of change. The emphasis on shared understanding was exactly the approach taken with the ALs on *M248*, many meetings were held to talk through the issues and explore possible solutions and barriers.

3. Results

3.1. Phase 1: Economics students Oct 2019 – June 2020

In 2017 and 2018 Economics students who completed the module tended to have a lower pass rate (92% in 2017 and 84% in 2018), compared to the BSc (hons) Mathematics (98% in 2017 and 99% in 2018) and BSc (Hons) Mathematics and Statistics students (93% in 2017 and 95% in 2018). Whilst this difference was not large the pass rate based on students who started the module was much more stark as students on the M&S qualifications have a greater module retention rate. One contributing factor was thought to be the limited prior knowledge of calculus possessed by non-M&S students. Whilst the calculus in *M248* is not difficult, and the ideas are presented from scratch, the concepts are challenging if this is a student's first exposure to calculus.

To address this issue study materials, covering the basics of calculus and explaining how these concepts were used by economists, were written by an *M248* AL who was an economist. The aim was for students to use this material during the summer prior to the module starting. Like most OU modules, students' study *M248* from October to the following June, enabling the summer months to be used to revise and refresh concepts. In mathematics and statistics all this material is embedded into one website, the Mathematics and Statistics Study Site, which students use as a one-stop-shop throughout their study (Hilliam et al, 2021). The study materials for the economists were embedded in the Mathematics and Statistics Study Site in May 2019 ready for students to use prior to starting *M248* in Oct 2019. The material included a handbook of techniques and supplementary example questions which were used in online tutorials for the economics students between June and September 2019. These tutorials were recorded for students who could not attend the sessions synchronously. Feedback from students, was generally positive with comments such as:

"I found the recording helpful to do a general refresher of calculus from a different angle."

It seemed that the provision of dedicated study materials may have helped to improve outcomes for the Economics students although it did not completely solve the problem, as economics students still had a lower pass rate 95% compared to the 98% for the BSc (Hons) Mathematics and Statistics students. However qualitative evaluation of the economics support suggested that students appreciated having dedicated support which linked the statistics to their qualification. This led to exploring whether it would be possible to provide dedicated tutorials for the four qualification-based groups shown in Figure 1.

3.2. Phase 2: Pilot of qualification-based tutorials for Oct 2020 – June 2021

Qualitative feedback from the pre-module economics sessions suggested these had created a feeling of community amongst the economics students. To attempt to recreate this same community feel for all the four qualification-based groups during the module bespoke tutorials for each of the four groups were designed. Each AL had historically provided 10 hours of tutorials, each tutorial covering the material in a particular unit. It was agreed that the overall time allocated for ALs to deliver tutorials would be rearranged/split into time for core tutorials – which is like the existing provision – and dedicated qualification-based tutorials. Furthermore each AL's group of 20 students were from the same qualification-based group. The project team felt this change in support would become increasingly important as the numbers of non-M&S students were set to increase. This increase was due to the introduction in 2019 of the new qualifications in Economics and Data Science. It was likely that larger numbers of students on these two qualifications would start to study *M248* from 2020 onwards.

Murphy (2016) explain that resistance in any long-term change project can appear at any point, however it is most likely to be apparent during the phase before change takes place. Therefore, to ensure the ALs were part of this process, regular online meetings between project team and ALs for

the sharing and discussion of information were introduced. The changing distribution of students on *M248* were not widely acknowledged by the ALs. Hence data was shared in the online meetings regarding the two new degrees and the changing distribution of the students. The sessions enabled, the idea of each AL having a group of 20 students who were in the same qualification-based group to be slowly introduced. Until this point ALs had been used to supporting a group of students in a particular geographical area who could be studying 20 different qualifications. These sessions took place over a year, giving ALs several opportunities to voice their views before a consensus was reached. It was agreed that each tutor group would consist of students on one of the four qualification-based groups: M&S, Data Science, Economics, and Open, as in Table 1. This would allow each AL to focus on how best to offer correspondence tuition to a particular set of students.

The ALs raised two specific concerns with the proposal regarding competency and fairness of workload. Each of the ALs had originally been recruited to teach primarily M&S students and had limited expertise in data science, economics, or other STEM areas. Therefore, several ALs were concerned they would be unable to find suitable examples to construct qualification-based tutorials. It was therefore agreed that tutorial material, could be written for each of the qualification-based groups, by small number of ALs. This team of ALs all had experience of either working or teaching in Economics, Data Science, or specialising in explaining statistics to non-statisticians. This followed the same pattern which had been used in Phase 1 of the project to write pre-module material for economics students. The intention was to provide a suite of materials that all ALs could use depending on the type of tutorial they were timetabled to provide. The second issue of fairness of workload centred around a concern that the non-M&S students would generally be weaker students and require more support. This was addressed by reducing the number of tutorials that ALs with non-M&S students would be required to give so that they could use the extra time to support their group.

To pay the group of ALs who were creating the new qualification-based tutorial material and to evaluate the effectiveness of this new way of working, funding was acquired from the OU centre for STEM pedagogy, eSTEeM. The students were surveyed in February and May 2019 in order to identify which areas of the module they found tricky, Unit 7 (which covers likelihood) was found to be particularly problematic, followed by Units 5, 10 and 11. Synchronous attendance, and viewings of the recordings of tutorials, for the Oct 2019-Jun 2020 students, also indicated these were areas were students sort more support.

Due to time-constraints qualification-based tutorial material was produced for only a subset of the 12 units which could be used for Oct 2020 – June 2021. And based on the results of the questionnaires the ALs focussed on providing material for those units which had been identified as more challenging. In total the students had access to 47 core tutorials (covering all 12 units), 3 M&S qualification-based tutorials, 6 Economics qualification-based tutorials, 6 Data Science qualification-based tutorials and 8 Open qualification-based tutorials. In core tutorials the ALs were free to identify key elements in the printed materials to expand on, explain and provide examples for students to tackle. The core tutorials for each Unit were usually 90 minutes in length. The qualification-based tutorials used the material which had been written by the specialist ALs and were typically shorter in length, usually 1 hour. These focused on examples from one of the four qualification-based groups. This distinction resulted in the qualification-based tutorials having a more informal feel, with an emphasis on students tackling questions in the session.

In December 2020 students were invited to feedback on the tutorial provision through an anonymous questionnaire. This consisted of open-ended questions which were analysed using text-based analysis. As OU students tend to provide positive comments to such questionnaires, the questions for the *M248* students were phrased in a way to elicit negative responses. For example, one question asked students to complete the sentence: "One thing that really irritates me about *M248* tutorials

is…". Figure 3 shows how the responses were split between the different qualification groups, together with the relative number of positive and negative responses to questions from qualification-based group. The Economics qualification-based group represented 9% of the responses to the questionnaire but contributed 15% of the positive words and 15% of the negative words. They therefore represented a more vocal group than their numbers suggested, but they were equally positive as negative. The least vocal group were the M&S qualification-based group who represented 39% of the respondents, like the economists these students were equally likely to respond positively or negatively (33% compared to 32%). The Data Science qualification-based group contributed 16% of the responses, but 27% of the positive words and were therefore the most positive group. The least positive group were the Open qualification-based group.
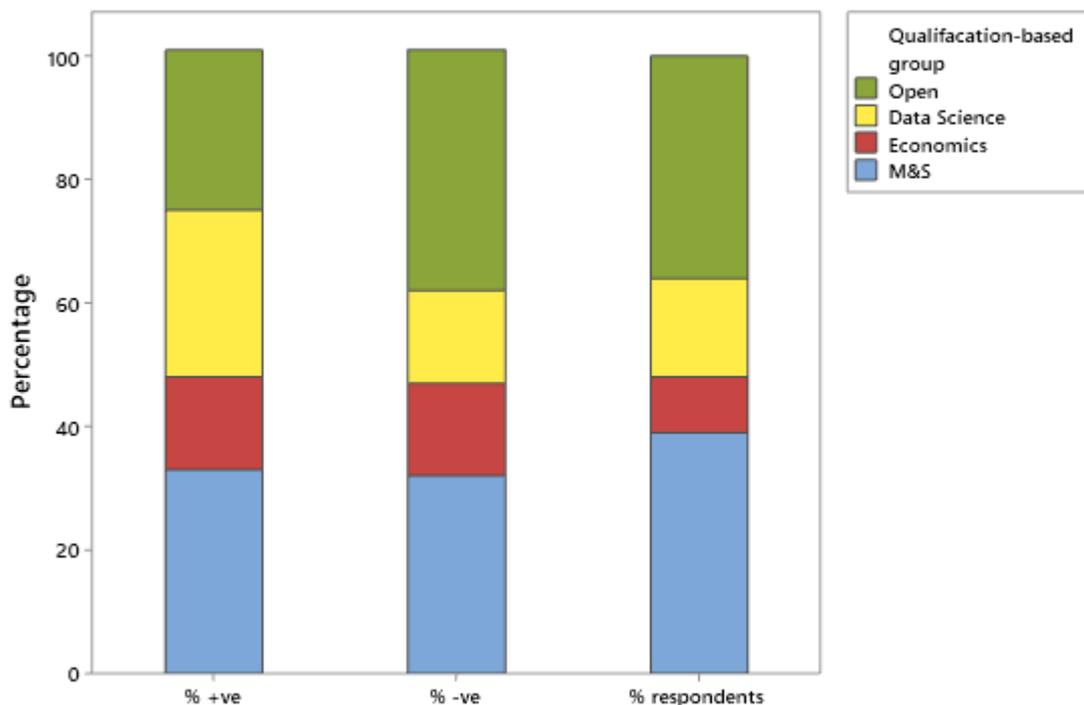

Figure 3. Percentage of positive and negative free text word responses by qualification group.

All tutorials, both core and qualification-based, were open to every student, however there was no evidence that, for example, a student from the Economics qualification-based group would attend a tutorial targeted at the M&S qualification-based group. Whilst there were only 3 M&S qualification-based tutorials it was assumed these students would attend the core tutorials. However, the M&S students expressed regret that they did not have more qualification-based tutorials, this was therefore rectified ready for Oct 2021. Table 2 shows the synchronous attendance and viewing of the recording for the different types of tutorials. Rather than absolute numbers these numbers are scaled by per hundred students or viewings to aid with comparison. The figures suggest that if a student was going to attend a tutorial synchronously, they were more likely to attend a qualification-based tutorial. Whereas, if a student was going to view a recording of a tutorial, they were more likely to view a core tutorial. This makes sense as the qualification-based tutorials had a more informal atmosphere and tended to have more student participation.

Tutorial type	Synchronous attendance per 100 students	Viewing per 100 students	Divisor
Core	4.2	697.0	Number of students on M248
Qualification -based M&S	6.1	54.5	Number of students in the named qualification-based group
Qualification-based Economics	9.4	16.9	
Qualification-based Data Science	11.4	224.0	
Qualification-based Open	8.2	331.0	

Table 2. Attendance and viewing figures for the 2020 cohort.

The Covid19 pandemic meant that exam conditions for each of the cohorts of students from 2018-2020 were very different and therefore comparison of exam results is not entirely useful. Students did however report that they felt more able to express their misunderstandings in the more supportive and inclusive environment which qualification-based tutorials provided.

3.3. Phase 3: Qualification-based tutorials for Oct 2021-June 2022

Based on the positive feedback from the Oct 2020-June 2021 students, more qualification-based tutorials were written ready for the Oct 2021 cohort. This has resulted in every unit having a qualification-based tutorial, for each of the four qualification-based tutorial groups, in addition to the core tutorials.

As student numbers had increased, 18 new ALs, including 7 of whom were new to the OU, were recruited ready for Oct 2021. Unlike previous years, ALs were recruited who were qualified and willing to teach a statistics module to non-M&S students. Whilst finding people with expertise in economics and data science remains problematic, the existing ALs were far more enthusiastic about taking a non-M&S group. This was a huge change from Phase 2 where only half the ALs expressed a willingness to take any qualification-based group. In Phase 3 no AL wanted to move from their allocated qualification-based group to a M&S qualification-based group. Furthermore, ALs expressed how much they had enjoyed the challenge of explaining statistics to non-specialists. The high level of discussion that had taken place during Phase 2 between the ALs has continued into Phase 3. There are now 40 ALs and the new ALs are very enthusiastic about building on the changes introduced with the original cohort of 22 ALs.

Both students and ALs feel that the qualification-based tutorials provide an environment where students can express their misunderstanding more openly as they feel they are amongst peers. This has increased the level of synchronous engagement in these tutorials. In addition, students can see the benefit of statistics within their own qualification.

4. Summary

The project grew out of a realisation that there were increased numbers of students taking the statistics module as part of non-M&S qualifications, many of whom were lacking some essential mathematical pre-requisite knowledge. As the actual module material could not be altered, changing the way in which students were supported was suggested as one possible solution. This involved highlighting issues and helping ALs who provided the support to understand there was a problem. The inclusive approach allowed the project team to collaborate with the ALs to create a new way of supporting students on different qualifications. As the project has evolved the team have worked with ALs to increase the level of interaction in qualification-based tutorials and use these tutorials to provide places where students feel comfortable expressing their misunderstandings. In addition, the type of comments provided to students who have differing qualification goals through correspondence tuition has been encouraged.

Due to the differences in exam arrangements over the period of the project it has not been possible to evaluate whether the new support has had any effect on the pass rate of different qualification-based groups. However, the surveys and feedback from ALs suggest that the qualification-based tutorials offer a more relaxed online environment for students. This enables them to feel more comfortable amongst their peers to discuss problems and ask for help. In addition, they feel they are not alone in their difficulties and see how statistics is used within their chosen discipline. The project team believe this method of qualification-based support could help students who suffer from statistics anxiety. It should be noted that statistics anxiety, is different – albeit related to – mathematics anxiety and various scales such as the Statistics Anxiety Rating Scales (STARS) were developed to address this difference (Cruise, Cash and Bolton, 1985). During the next two years the project team will use statistics anxiety rating scales such as STARS to evaluate whether students in the different qualification groups suffer from different types of statistics anxieties and whether interventions before the start of the module and during the qualification-based tutorials could be delivered to alleviate these issues.

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