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Statistics Support and Anxiety Explored

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Most higher education institutions in the UK now offer some form of additional individual support for mathematics and statistics. Whilst numerous studies have shown mathematics support can improve grades and reduce failure rates, there is a lack of research on other outcomes of interest such as anxiety or confidence, and very little research relating specifically to statistics support. This study uses quantitative and qualitative results from student questionnaires to evaluate the effectiveness of support in reducing anxiety and increasing confidence immediately after the first statistics support session and in the longer term. Comparisons of and preferences for online or face to face sessions and other aspects relating to anxiety were also explored. Key quantitative findings include a significant reduction in statistics anxiety after only one session of statistics support and a long-term increase in confidence with statistics. When asked how support impacts on anxiety or confidence, key themes emerging included feeling comfortable asking questions in statistics support, tailoring to individual needs and confirmation of understanding. The majority of students preferred face to face sessions over online particularly those with higher levels of statistics anxiety. Although differences were generally not significant, higher levels of anxiety were observed before online sessions and greater changes in anxiety occurred during face to face sessions.

Keywords: statistics support; statistics anxiety; mathematics confidence, statistics education.

1. Introduction

1.1. *Overview of statistics anxiety and impact*

Mathematics and statistics anxiety are common situation-specific anxieties which, unlike trait anxiety, are only triggered in mathematical or statistical situations (Baloglu, 1999). For example, Cruise et al., (1985) describe statistics anxiety as "the specific feelings of anxiety students experience when they encounter statistics, for example, gathering, processing, and interpreting data." Statistics anxiety is particularly prevalent in higher education as statistics is widely taught across non-specialist disciplines.

If a student believes that they cannot learn statistics and perceives statistics as a threat to their wellbeing, perhaps due to negative experiences with mathematics or statistics in the past, anxiety can trigger a fight or flight response (Johnston-Wilder et al., 2020). Such students are likely to experience symptoms such as racing heartbeat, restlessness, mental disorganisation, difficulty concentrating, fast breathing, sweating, panic and being "hyped up" (Zeidner, 1991; Baloglu, 1999). Justicia-Galiano et al. (2016) showed that students with higher levels of mathematics or statistics anxiety had higher levels of intrusive thoughts and were less able to regulate their emotions or suppress these negative thoughts.

Anxiety interferes with working memory as the brain is too busy worrying to be able to concentrate on doing the work, making the work seem harder than it is (Young et al., 2012). Students in a state of anxiety will struggle to learn effectively and are more likely to employ ineffective learning behaviours such as avoidance (Williams, 2010), procrastination (Onwuegbuzie, 2004), or failing to seek help, which can subsequently lead to poorer performance (Macher et al., 2012; Paechter et al., 2017, Shaker

et al., 2021). Statistics anxiety can impede a student's ability to engage with tasks such as interpretating and analysing statistical data or understanding research articles.

Self-efficacy is the belief or confidence in one's ability to complete a specific task or goal (Bandura, 1997) which Parsons et al. (2009) referred to as 'Topic Confidence' with regard to mathematics and statistics. Parsons et al. (2009) and Warwick (2008) show that mathematics self-efficacy impacts on engagement and achievement. Finney & Schraw, (2003) separate self-efficacy based on current statistics ability and self-efficacy to learn statistics, although both scales to measure these separate constructs are based on asking people to rate their confidence. Students' statistics self-efficacy is related to anxiety about statistics (McGrath et al., 2015) and grades particularly if measured close to times of assessment (Finney & Schraw, 2003). Student's self-efficacy can be influenced by verbal persuasion from others, particularly knowledgeable figures such as teachers. However, the main determinant of self-efficacy is performance evidence or mastery of skills (Warwick, 2008; Bandura, 1997).

Although there is a relationship between mathematics and statistics anxiety, and a lack of confidence or background in mathematics has been linked to poor performance in statistics modules (Paechter et al., 2017; Macher et al., 2012), statistics anxiety has more often been identified as a separate construct to mathematics anxiety (Zeidner, 1991). As types of situational anxiety, mathematics and statistics anxiety are triggered only when a student encounters mathematics or statistics. Whilst the triggers differ between the two, it is likely there are similar impacts on student learning and the strategies to address the anxiety are therefore relevant to both. Research specifically relating to statistics anxiety has identified that instructional methods such as fast-paced learning, too much mathematical content, high stakes assessment without the opportunity of feedback, and lack of support from teaching staff can contribute to anxiety about statistics (Cui et al, 2019) although some of these factors may also impact on other types of academic anxiety. Negative attitudes to statistics, lack of interest and failing to see the relevance of learning statistics have also been linked to higher levels of statistics anxiety and lower performance (Finney & Schraw, 2003; Chiesi & Primi, 2010; Marshall et al., 2021). For many students, and particularly those who experience mathematics or statistics anxiety, positive learning experiences are key to helping break the cycle of avoidance, non-engagement, and poor student performance.

Individual mathematics and statistics support can potentially provide positive experiences in learning, build confidence and reduce anxiety. However, there is a distinct lack of research evaluating the impact of such support on outcomes such as anxiety and confidence particularly for statistics support. Due to the lack of research relating specifically to statistics support, this paper outlines relevant research on mathematics support, mathematics anxiety and instructional techniques or strategies for reducing academic anxiety.

1.2. *Mathematics and statistics support*

Many universities in the UK now have a dedicated Mathematics Support Centre (MSC) (Ahmed et al., 2018; Grove et al., 2020), which provide extra-curricular mathematics teaching and support for individuals. The provision of formal mathematics support was initially in response to a drop in mathematical literacy within schools and high failure rates in the mathematics modules on engineering courses in the UK (Lawson et al., 2020) and Australia (Rylands & Shearman, 2018), leading to potential problems with retention. Although engineering students were initially the main users of mathematics support, Lawson et al. (2003) report that mathematical or statistical ability impacts on progression within many disciplines. Furthermore, Lawson et al. (2020) discuss the growing demand from employers for students with quantitative skills and increased use of numerical reasoning tests. MSCs vary in size and provision, but most are open to students from a variety of disciplines and offer drop-in support provided by academics, staff employed specifically for

delivering support or doctoral students. Some MSCs also offer diagnostic testing, bookable appointments and workshops.

Most centres also now offer some form of statistics support, but unlike mathematics support, which focuses on support with taught mathematics material, statistics support often extends to final year or postgraduate students undertaking quantitative research from a wide range of disciplines (Lawson et al., 2020; Owen & Marshall, 2015). In addition to deficiencies in statistical literacy of students, Lawson et al. (2020) also highlight the growing concerns of numerous professional bodies surrounding the lack of staff equipped to deal with the teaching of quantitative skills. Anecdotal evidence from statistics support staff suggests that a growing number of disciplines now expect students to carry out quantitative research but provide little or no teaching within the curriculum, and supervisors often lack the basic knowledge to provide advice. Lawson et al. (2003) report that staff in some centres feel that the presence of an MSC can encourage some departments to rely on this as the sole method for teaching mathematics rather than additional support for existing teaching. *Marshall & Owen (2019) summarise concerns of statistics support staff regarding providing teaching rather than support, being seen as supervisory surrogates particularly for masters dissertations and supervisors suggesting inappropriate techniques due to lack of statistical knowledge.*

1.3. *Evaluation of mathematics and statistics support*

Both Lawson et al. (2020) and Dzator & Dzator (2018) give useful summaries of research relating to mathematics support, which tends to focus on characteristics of users, or comparison of grades for users and non-users of mathematics support, and primarily with engineering cohorts. Some mathematics support centres carry out diagnostic testing of engineers at the start of the first year of study to identify students needing additional support, which can be used with MSC attendance and end of year grade to show improvement. Several studies found significant differences in pass rate or end of year grade for MSC users compared to non-users (Patel & Little, 2006; Dowling & Nolan, 2006; Mac an Bhaird et al., 2013). Others showed a significantly higher pass rate for students deemed at risk of failing if they used MSC support (Pell & Croft, 2008; Hillock et al., 2013; Dowling & Nolan, 2006). For students achieving lower grades on the diagnostic tests, some MSCs use additional workshops which have been associated with higher final grades (Rylands & Shearman, 2018; Hillock et al., 2013). Mathematics support was traditionally aimed at students 'at-risk' of dropping out. Studies in Ireland (Carroll & Gill, 2015; Ni Fhloinn et al., 2014) and Australia (Dzator & Dzator, 2018) reported that 10-39% of MSC users had considered dropping out due to mathematical difficulties but that many cited MSC support as influencing their decision not to drop out. These same studies also showed improvements in mathematics attitude and study habits as a result of using mathematics support, although the measures were binary and collected at the end of the year. There are recognised issues with collecting data at the end of the year, as it can be difficult to distinguish between the direct effects of mathematics support and other factors contributing to performance (MacGillivray & Croft, 2011). Another issue when assessing impact, particularly on performance, is that although mathematics support was initially aimed at students with a weaker mathematical ability, MSC support is generally not restricted to these students (Pell & Croft, 2008). Therefore, stronger or more motivated students looking to improve their grade could be contributing to higher grades for MSC users (Lawson et al., 2003).

1.3.1. Confidence, anxiety and support

As well as the practical support that can be provided, students also expect staff in support centres to offer emotional support (Lawson et al., 2003), but there is little literature expanding on the level of emotional support required, how to provide emotional support, or evaluation of the impact. Johnston-Wilder has numerous publications on using emotional coaching to increase mathematical (Johnston-Wilder et al., 2020) and statistical resilience (Johnston-Wilder et al., 2018) on an individual basis or within group settings on a longer-term basis. In 2017, Johnston-Wilder & Marshall (2017) adapted

these emotional coaching methods to suggest how short-term support for highly anxious students could be provided in a MSC setting. The authors of this paper have also developed a workshop on addressing statistics anxiety delivered through statistics support and self-help resources for students and staff (Marshall, Riach, Shaker & Haigney, 2022b). For educators, recognising when a student is in a state of anxiety and addressing the anxiety is an important step before meaningful learning can happen (Johnston-Wilder, 2018; Johnston-Wilder, 2020; Johnston-Wilder & Marshall, 2017). When students recognise the impact of mathematics anxiety on learning and are aware and can monitor their emotional state, particularly negative beliefs, a reduction in mathematics anxiety can be achieved (Martinez & Martinez, 1996; Uusimaki & Kidman, 2004).

During the pandemic, Smith (2022) asked students to rate their perceived mathematics anxiety, before an online support session, before a face to face session and generally and found that students' perceived anxiety scores immediately before an in-person mathematics support session were significantly higher compared with mathematics anxiety in general, and immediately prior to an online session. Regarding non-engagement with MSCs, O'Sullivan et al. (2014) reported that mathematics anxiety was one of the main reasons students did not engage with mathematics support, but Gokhool et al. (2022) found a higher mean mathematics anxiety within students who had used the service, suggesting some anxious students do engage with mathematics support. The authors of this paper also found that whilst those attending optional statistics anxiety workshops provided for students had higher levels of statistics anxiety, feeling too anxious and higher levels of help-seeking anxiety were the main reasons for non-attendance (Marshall et al., 2022b). A large-scale multi institution Irish study (Ni Fhloinn et al., 2014) asked how helpful mathematics support was regarding mathematics confidence on a 5 point scale, with 56% of students feeling it had been helpful or very helpful in an end of year survey. Two studies, Carroll & Gill (2015) and Dzator & Dzator (2018) asked students whether or not using mathematics support had made them feel more confident about their ability in mathematics with 86% and 63% responding yes respectively. Wilkins (2015) measured confidence in the specific mathematical topic students asked for help with on a 5-point scale before and after receiving the support from a learning development mathematics tutor and saw a significant increase. There was also a significant increase in confidence in mathematics generally from before their first session compared to the end of the year. Although the sample size for the end of year feedback was low which is a recognised problem when evaluating support services. Choudhary & Maltus (2017) report a small, significant reduction in mathematics anxiety after a series of additional numeracy tutorials run by mathematics support. These were associated with an increase in test scores, therefore performance experience is likely to have increased self-efficacy and led to the decreased anxiety.

1.3.2. Why is mathematics and statistics support effective?

Literature on why mathematics and statistics support is effective for reducing anxiety, increasing confidence or improving understanding is limited, particularly around statistics and anxiety. Although there is relevant research on mathematics anxiety and instructional methods evaluated in classroom settings for both maths and statistics. Students who are anxious about mathematics or statistics need to replace their previous negative experiences of mathematics with positive interactions from staff who are knowledgeable, enthusiastic and show belief in the student's ability to succeed (Finlayson, 2014). MSCs can facilitate provision of a relaxing, non-threatening and supportive environment for students to learn at their own pace (Lawson et al., 2003; Patel & Little, 2006) but the quality and knowledge of the staff employed at the MSC is also important (Lawson et al., 2020; Fitzmaurice & Mac an Bhaird, 2021) to meet the diverse emotional and cognitive needs of students requiring support. Staff at MSCs can be postgraduate tutors, lecturers who provide a few hours of support a week, or staff employed specifically to work at MSCs, so support will vary by institution, tutor and experience. Tutors need to be welcoming, patient, flexible in their approach to teaching, non-judgemental and have well-developed teaching skills (Lawson et al., 2020), making recruitment and training of new tutors an important consideration, particularly when dealing with anxious students.

Tackling anxiety within MSCs or the classroom is likely to require a multi-stage approach, starting with acknowledging anxiety or concerns (Wilson, 2006; Johnston-Wilder & Marshall, 2017), changing the content or instructional methods (Pan & Tang, 2004; McGrath et al., 2015) and instructor behaviour (Williams, 2010; Waples, 2016; Tonsing, 2018).

Methods for reducing mathematics anxiety include ensuring a comfortable atmosphere, encouragement from staff and additional support outside the classroom, (Woodard, 2004; Jackson & Leffingwell, 1999). Núñez-Peña et al. (2015) found that mathematics anxiety was a significant predictor of final grade in a Research Design course for Psychology students, but after the introduction of assessment feedback classes, this relationship was weakened, suggesting that feedback reduces anxiety. Marson (2007) used qualitative student responses to show that immediate individual feedback on assessments with the opportunity to address errors was an effective method for improving understanding of statistics. Common themes emerging from the qualitative comments about mathematics support compared to lectures in Carroll & Gill (2015), Daztor & Dzator (2018) and Ni Fhloinn et al. (2014), include the slower pace, more detailed, clearer explanations, usefulness of having concepts explained by someone other than their lecturer, having someone there when you get stuck, feeling more comfortable asking questions and more encouragement that built confidence.

Educational research into the impact of instructor behaviour suggests that the interpersonal style of the teacher particularly immediacy behaviours can impact on learning outcomes generally (Witt et al, 2004). The link between immediacy and anxiety is more relevant to the non-specialist teaching of mathematics and statistics where prevalence of these subject specific academic anxieties is more common and more research into what can cause or address this anxiety is therefore carried out.

Immediacy relates to positive communicative behaviours of instructors and students' perception of how approachable or available they are. Non-verbal behaviours include smiling to the whole class, eye contact, being relaxed, gestures when speaking and moving around the classroom. Verbal behaviours include initiating conversation with students inside and outside class, using student names, encouraging students to talk and share opinions, and sharing personal experiences.

Several papers investigate immediacy behaviours of instructors in statistics courses and how these impact on statistics anxiety, confidence and learning outcomes (Williams, 2010; Tonsing, 2018; McGrath et al., 2010; Wilson, 2006) and Kelly et al (2020) investigate the relationship regarding mathematics. Williams (2010) and Tonsing (2018) showed that non-verbal instructor immediacy behaviours were positively related to levels of interest, student self-concept and lower levels of interpretation and test/class anxiety as measured by STARS. Williams (2010) actively practised immediacy behaviours with a group of students and found they had significantly lower levels of interpretation and test/class anxiety and were less fearful of statistics instructors than a control group. Wilson (2006) showed students were more motivated to learn when instructors show concern for students and demonstrate more immediacy in their approach. Wilson (1999) reported qualitative responses from students on aspects of teaching which reduced anxiety included individual support, acknowledging anxiety, breaking learning into small steps and using humour. Students participating in Lalayants (2012) study also identified these aspects as important for the effective teaching of statistics along with being patient, creating a non-threatening classroom where they felt comfortable asking questions and demonstrating the relevance of statistics to their chosen field. Pan & Tang (2004) and McGrath et al. (2015) found significant reductions in statistics anxiety after implementing several strategies within the classroom including acknowledging anxiety, application-based teaching using relevant examples, offering individual additional support outside of the class and focusing on the attentiveness of instructors within the classroom. Waples (2018) advocates the importance of building an emotional rapport between instructor and student alongside cognitive learning in order to increase self-efficacy. Providing an emotionally secure environment, with opportunity to receive

regular positive feedback and encouragement, increases self-efficacy and subsequently perseverance with more difficult tasks.

Onweugbuzie (2000) and Pan & Tang (2004) identified an apprehension of approaching statistics lecturers for help due to fear of looking incompetent, and Cruise et al. (1985) included fear of statistics lecturers as a dimension of statistics anxiety in the Statistics Anxiety Rating Scale (STARS). Most students lack intrinsic motivation to learn statistics within the curriculum as they may fail to see the relevance of the topic, and lack of interest is related to statistics anxiety (Chiesi & Primi, 2010; Schutz, 1998), but both Sandoz et al. (2017) and Marshall et al. (2021) found that if highly anxious students are intrinsically motivated to learn, they can overcome their anxiety and outperform less anxious students. Engaging students with statistics, for example by using real life data which is relevant to the students (Neumann et al., 2013; Pan & Tang, 2004; Marson, 2007; Lalayants, 2012), can increase intrinsic motivation, and students who are interested will employ more effective learning strategies (Chiesi & Primi, 2010; Macher et al., 2012) such as help seeking and perseverance.

Students using statistics support often require assistance with research projects and are therefore likely to be more motivated to understand the statistics because it is relevant to their research. As support is primarily on an individual basis, immediate feedback on understanding and immediacy behaviours such as close communication, eye contact, use of student names and smiling will help ensure students receive the positive verbal persuasion and encouragement needed to reduce their anxiety and increase self-efficacy with statistics. When delivering support online, particularly when cameras are turned off, immediacy behaviours which help students feel relaxed or comfortable may be less apparent. In addition, issues with technology and lack of tutor contact whilst waiting for online drop in support may also increase anxiety. In a previous study on students studying remotely in 2020/21 Marshall et al., (2022a) reported that problems with technology and poor emotional wellbeing during the year of remote learning negatively impacted on statistics anxiety and students feeling able to learn effectively. It was anticipated that there may be differences in anxiety and changes to anxiety for different session types, such as online compared to face to face and appointments in comparison to drop in support. Therefore these aspects are investigated as part of this paper.

1.4. Aims

While anecdotal evidence exists from those working in statistics support that MSCs can provide an ideal setting in which students can experience a reduction in statistics anxiety and increase in confidence, no study has formally evaluated this or explored why students feel statistics support is beneficial. This study evaluates statistics support provided at Sheffield Hallam University and the University of York using statistics anxiety and confidence scales, and students perception of changes. In particular, change in statistics anxiety during a first statistics support session and in the longer term is assessed, and qualitative results are used to understand why students feel statistics support is beneficial. Key research questions addressed in this paper include:

1. How anxious about statistics are students engaging with statistics support?
2. What are the immediate and longer term effects of statistics support with regard to reducing anxiety and building confidence with statistics?
3. Do anxiety levels and changes differ for students attending on-campus and online support?
4. What are the benefits of statistics support from the student perspective?

2. Methods

2.1. Statistics support at Sheffield Hallam and University of York

The statistics support services at both Sheffield Hallam and University of York are open to students studying any subject, and attendance is an optional extra that is not part of a student's course. Services were advertised in various ways including lecturers recommending statistics support services, peer-to-peer word of mouth, leaflets, posters and digital adverts. Both institutions offered appointments and

drop-in sessions running at advertised times, but the number of appointments and drop-in sessions offered fluctuated with demand.

The Maths Skills Centre at the University of York was not connected to any particular department and has a dedicated space within the library. Students talked to members of staff, some of whom are doctoral students, who are trained in tutoring statistics. Prior to March 2020, when the data from York students was gathered, all provision was on campus, with two statistics drop-ins per week and statistics appointments available to book most weekdays.

At Sheffield Hallam, the majority of statistics support was provided by one statistics lecturer from the Department of Engineering and Mathematics who specialises in statistics support provision. During busy periods, other academic staff or Psychology doctoral students also saw students. On-campus support took place in computer rooms within the libraries of the two campuses and there was a weekly online drop in session, shared with other academic skills services, which started running throughout the year during the first lockdown. On-campus drop-in sessions and appointments were the only method of delivery prior to March 2020. Between March 2020 and November 2021, there was one weekly online drop-in session, and bookable thirty minute online appointments with on-campus provision during term time offered again in addition to online from November 2021. Drop in attendance varies considerably during the year and during peak times students may have to wait a long time to be seen and spend less time with a tutor which may impact on stress levels.

It should be noted that the authors of this paper deliver workshops on reducing statistics anxiety, have developed statistics anxiety resources for use by students and staff and therefore may differ slightly in their approaches compared to other statistics support staff, which may have impacted on feedback from students using the service.

2.2. *Data collection*

To address the research questions, three voluntary questionnaires were developed in Qualtrics (www.qualtrics.com/uk/). Ethical approval was granted by the Sheffield Hallam University's Ethics Committee and the University of York's Department of Education Ethics Board. Of most interest were students visiting statistics support for the first time so the impact of one support session on anxiety and confidence could be measured using pre and post first session questionnaires. Potential participants for the pre and post first session surveys were students accessing the service for the first time who could be from any year (first year undergraduate to PhD student) and from any subject.

Data collection commenced in January 2020 when all support was face to face at both institutions and most students attending sessions were invited to participate. Data collection at the University of York did not resume after the interruption caused by the Covid-19 pandemic in March 2020. Therefore, University of York students all attended face-to-face sessions and did not participate in the end of year survey with very few completing the post first session and results in the paper relate predominantly to Sheffield Hallam students. Although the numbers participating was substantially reduced following the move to online learning, data collection at Sheffield Hallam continued until May 2023.

Students attending drop in sessions were invited to participate in the study whilst waiting for their turn or to log into a computers and the option of filling out surveys either on paper or online. As it was not considered appropriate to take up actual appointment time, students booking appointments received a link to the pre questionnaire in the booking confirmation email for online appointments but as students could book up to two weeks in advance, this meant there was potentially a larger gap between pre and post than drop in visits. It was made clear that participation was voluntary and would not affect the support they received. Students had access to information for participants and a declaration of consent was required before the rest of the survey could be completed.

The same students were also asked to fill in the questionnaire after their first session either straight after the session or in a link to the post questionnaire in an email which was sent out either on the day or up to 2 days after they had used the service.

All statistics support users at Sheffield Hallam received an email at the end of each academic year inviting them to participate in the end of year study but response rate was very low. In addition, Sheffield Hallam participants were matched with statistics support attendance records using student ID's to identify the type of session first attended, how many sessions they had attended and other session information so analysis on session type and the end of year survey are restricted to Sheffield Hallam students only.

2.3. Scales measuring statistics anxiety and confidence

As statistics anxiety is thought to be multi-dimensional (Cruise, Cash & Bolton, 1985), several different measures of statistics anxiety were used in the study. All the statistics anxiety scales ask students to rate their level of anxiety in different situations on a seven-point scale ranging from 1 (not at all anxious), to 7 (extremely anxious). The items in the scales are listed in Appendix A alongside Cronbach's alpha scores calculated using the responses to the pre survey which had the highest number of participants.

The Statistical Anxiety Rating Scale (STARS; Cruise et al., 1985) and the Statistical Anxiety Measure scale (SAM; Earp, 2007) both contain subscales relating to anxiety and attitudes but only the anxiety subscales were used in this study. The anxiety SAM scale is a more general and reduced version of the interpretation and class/test subscales from STARS but does not include anxiety about seeking help so the STARS subscale is used to represent this dimension of statistics anxiety and the item about anxiety about choosing the right test from STARS was also added to the questionnaires. Neither STARS or SAM measure anxiety around using software so a three-item scale developed by the authors was included. Using factor analysis on the data in this study, both software and help seeking anxiety were shown to be separate dimensions from the SAM anxiety scale. Although multi-item scales are often used to measure underlying latent variables, Sauro (2018) and Robinson (2017) report on several studies showing that single-item scales can be used successfully to represent longer scales especially if there are a wider range of equidistant, numerical responses (Harpe, 2015), such as the 7-point anxiety range in our items. Given anxiety in very specific situations is being measured, it seems unnecessary to have multiple items asking something very similar. Making minor modifications to existing scale items should retain the validity of the original scales and where there are subscales shown to differ in factor analysis, they should be analysed separately (Robinson, 2017). The two questions on asking lecturers for help from STARS were considered separately to the one asking students for help after initial analysis suggested differences. For the end of year survey, an adaption of the STARS help seeking subscale related to fear of asking for help from lecturers but in reference to statistics support staff, so a comparison could be made.

To measure confidence, students were asked how much they agreed with four statements describing different aspects of quantitative research such as choosing the right test, using and interpreting statistical software and writing research reports all of which they can receive help with during statistics support sessions. A mean of the four scores is used to measure current confidence (Cronbach's alpha 0.88).

2.4. Student perception of change

In addition to the anxiety and confidence scales, the post and end of year surveys asked students if they thought using statistics support had impacted on their anxiety and confidence. This used a 5-point scale from feeling a lot less to a lot more anxious or confident (Appendix A) and asked about the topic they came in for help with and generally undertaking statistical analysis. There were additional statements at the end of the year on using software, interpretation and reporting of results.

These questions were included to get a measure of perceived change from the student perspective, particularly for students who had not completed a pre-session questionnaire and therefore could not be matched with pre-session scores. To get an overall measure of perceived change in the end of year survey, the responses for each of five items were coded from –2 (a lot more anxious) to 2 (a lot less anxious) and the mean taken for each student (Cronbach's alpha=0.91). The same approach was taken for the confidence questions, but with positive scores indicating an increase in confidence (Cronbach's alpha=0.92). As the number of people responding to more than one survey was expected to be low, students were asked their perceived levels of anxiety prior to using statistics support in the end of year survey.

Students were also asked some general questions in the support provided, whether they felt their supervisors could help with quantitative research and whether they had a preference for online or on campus support with an open question to understand preferences at the end of the year.
Students were asked to comment on the impact they thought statistics support had had on them, specifically prompting them to talk about reducing anxiety, building confidence and how it differs to "normal teaching" in the post session survey and at the end of the year. A second question asked for any other comments generally about statistics support, anxiety or learning statistics in the end of year survey.

2.5. *Data analysis*

Only Sheffield Hallam students participated in the end of year study, had session details matched with survey responses and only five students from the University of York took part in the post session survey. The University of York participants were therefore only included in the institution comparisons and paired t-test for pre and post first session.

Researchers often disagree on whether to use parametric measures for ordinal data, and several papers such as Harpe, (2015), Norman (2010) and Sullivan & Artino (2013) discuss common misconceptions and situations where using parametric techniques is suitable for ordinal data. Harpe (2015) presents results from several papers to suggest that if participants are presented with and use a wider range of numeric responses that the participant perceives as equally spaced and the assumptions of tests have been met, parametric tests can be used even for single-item scales. Norman (2010) challenges and tests parametric and non-parametric techniques on simulated data and found that parametric tests had more power and were robust to departures from normality even with single-items. Using means for some types of ordinal responses such as strongly disagree-strongly agree can be difficult to interpret but as this paper focuses on changes in anxiety and comparisons of different types of anxiety, using means across even the single item scales and parametric tests seems appropriate, consistent and allows a wider range of techniques to be used.

The means of each statistics anxiety subscale outlined in Appendix A were calculated for all participants at the three time points to give measurements of different types of statistics anxiety. Paired t-tests were used to test for changes in the different types of statistics anxiety for students who had completed the pre-session survey and either the post first session survey or the end of year survey.

Multivariate analysis of variance (MANOVA) is a method for comparing the impact of one or more categorical independent variables on multiple related dependent variables simultaneously and gives an overall test for all the subscales together, followed by tests for the individual types of anxiety which should be adjusted for multiple testing. Institutional differences for pre-session anxiety, reduction of anxiety by number of visits and change in anxiety between those attending the different session types, were all tested using MANOVA with Bonferroni adjusted follow up tests. When assessing whether the change in anxiety or confidence differed depending on session type, MANCOVA controlling for pre-session anxiety was used for the people taking both the pre and post first session surveys although this did reduce the sample size considerably.

For the end of year, scale means of reduction in anxiety, increase in confidence and perceived pre-course anxiety were calculated from the student perceptions questions and used to compare different groups. Correlations were used to assess relationships between anxiety and aspects such as preferences for online or face to face sessions, supervisory support and prior teaching of statistics on their course. A paired t-test was used to compare anxiety asking lecturers for help to asking statistics support staff for help for all students taking the end of year survey. 77 students responded to at least one of the open questions. These written answers were analysed qualitatively. Due to the similarity in the two questions, the responses did not differ in content, and sometimes even repeated ideas within a participant. Therefore, the data from both questions was analysed together. The analysis aimed to understand why students felt statistics support was beneficial. Thematic analysis was used with a data led, inductive approach to ensure that ideas outside of the researcher's beliefs were captured. After initial familiarisation with the data, codes that emerged from the data were assigned to text using a spreadsheet during iterative readings of the corpus. Once themes were established by comparing, contrasting, and combining codes, the themes were refined by referring back to the codes, corpus and research question. Descriptive names were given to the final themes.

2.6. Overview of participants

While 188 students agreed to fill in the pre questionnaire before visiting statistics support, only 31 of those also filled in the post questionnaire and only 19 of the original 188 filled in the end of year questionnaire. No students filled in all three questionnaires. 81% of respondents filling in the post first session feedback did so on the same day as their visit, making it easier to attribute change to statistics support. 33% of students filling in the end of year survey had last used statistics support in the previous month and 21% at least two months before. 32% of respondents filling in the end of year questionnaire had used the service once, 29% twice, and 39% three or more times.

Table 1 shows the number of participants who filled in a statistics anxiety questionnaire before their first statistics support session (pre), after their first support session (post) and at the end of the academic year (end), with a breakdown by key characteristics.

	Pre 1st session	Post 1st session	End of year
Sheffield Hallam participants	162	78	102
University of York participants	39	5	0
% female	86%	84%	83%
% Final year / masters	81%	74%	91%
% receiving help with dissertation	Not asked	70%	59%
First support session online (SHU)	72%	67%	73%
First support session a drop in (SHU)	56%	59%	54%

Table 1: Overview of participants of the three surveys

The majority of students filling in the pre/post questionnaires were either final year or masters students, which is consistent with the users of the service. The majority of final year students required support with dissertations whereas masters students were a mix of dissertation and module support. The high percentages of students having first sessions online, and lower percentages of drop in students, are due to the data collection period taking place partly during remote teaching when support was mostly provided via online appointments. For participants where department was identified, the majority of students filling in at least one survey were students from Psychology, Criminology, Business or health professionals.

3. Results

4.1. *How anxious about statistics are students engaging with statistics support?*
Responses for all statistics anxiety scales ranged from 1 Not at all anxious to 7 extremely anxious and Fig. 1 shows that prior to their first session most students were in the mid-high range particularly around choosing the right test suggesting that anxious students are engaging with statistics support.

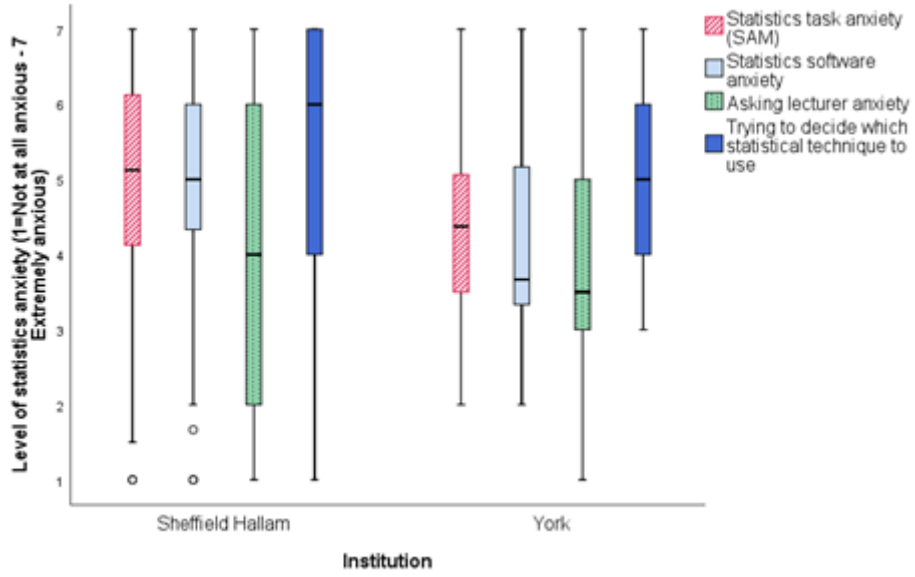

Fig. 1 Comparison of statistics anxiety scores by institution.

A MANOVA testing for general differences in statistics anxiety between the two institutions was significant [F(5,173)=3.96, p=0.002, Wilk's Lambda=0.897, partial η^2=0.10]. Sheffield Hallam students had significantly higher levels of general statistics task anxiety (p=0.02), software anxiety (p=0.005) and anxiety about asking other students for help (p=0.001) before their first statistics support session than the students from the University of York.

A previous study found that students' perceived mathematics anxiety prior to face to face sessions was higher than for online sessions (Smith, 2022), and students may feel more anxious attending a drop in session rather than an appointment with a named advisor. Session type was identified from attendance data to test for differences at Sheffield Hallam. Only three participants had attended a face to face appointment and therefore could not be analysed as a group and were combined with online appointments (N=66) and compared to online drop ins (N=43) and face to face (N=39) drop in sessions.

Although students attending face to face drop in sessions had slightly lower levels of help seeking anxiety than those attending online drop in sessions or appointments, the overall MANOVA testing for general differences in statistics anxiety between the three different session types was not significant [F(10,264)=0.645, p=0.775, Wilk's Lambda=0.953, partial η^2=0.024]. It should be noted that students attending drop in sessions tended to take the survey whilst waiting whereas students with appointments were invited to participate within their booking confirmation.

It was also of interest to assess whether final year or masters students using statistics support closer to dissertation deadlines are more anxious than those seeking help earlier so visits in Jan/Feb were compared with March/April (UG deadline), May/June and July/August (PG deadline). Although the MANOVA [F(15,246)=1.9, p=0.022, Wilk's Lambda=0.737, partial η^2=0.097] was significant, differences varied by anxiety type and the only significant difference was that those in July/August were more anxious about asking another student for help than those visiting in Jan/Feb.

4.2. *What are the immediate and longer term effects of statistics support with regard to reducing anxiety and building confidence with statistics?*

In order to assess the impact of statistics support on anxiety and confidence, two methods were used. Firstly, the statistics anxiety subscales were collected at each time point, so for those completing more than one survey, an objective measure of change could be calculated. However, as only 31 students completed both the pre and post session surveys, and only 19 took both the pre and end of year surveys, the tests have low power. In addition, students were asked directly whether they thought using statistics support had changed either their anxiety or confidence with regard to the topic they were seeking help with, and doing statistical analysis in general, each measured on 5 point 'A lot less – a lot more' scales.

4.2.1. Change in scale means for students taking two surveys

There were many significant differences when changes in anxiety and confidence scale means were compared using paired t-tests on students who had been measured at two different time points despite the small sample sizes (Table 2).

	Statistics anxiety measure					Confidence
Paired t-test p-values	**SAM statistics task**	**Statistics software**	**Asking lecturer for help**	**Asking student for help**	**Choosing the right technique**	**Confidence**
Pre-post (N=31)	0.022*	0.004**	0.017*	0.067	0.004**	0.411
Pre-end (N=19)	0.014*	0.002**	0.01*	0.385	0.112	0.01*

Table 2: Paired t-test p-values for analysing changes in different types of statistics anxiety.

Paired differences were calculated for each participant so that a 'positive change' indicates a reduction in anxiety or increase in confidence from before their first statistics support session (Fig. 2). All anxieties were reduced particularly around software and asking lecturers for help. The reduction in anxiety about choosing the right test was only significant straight after the first session and confidence in undertaking statistical tasks increased by the end of year only.

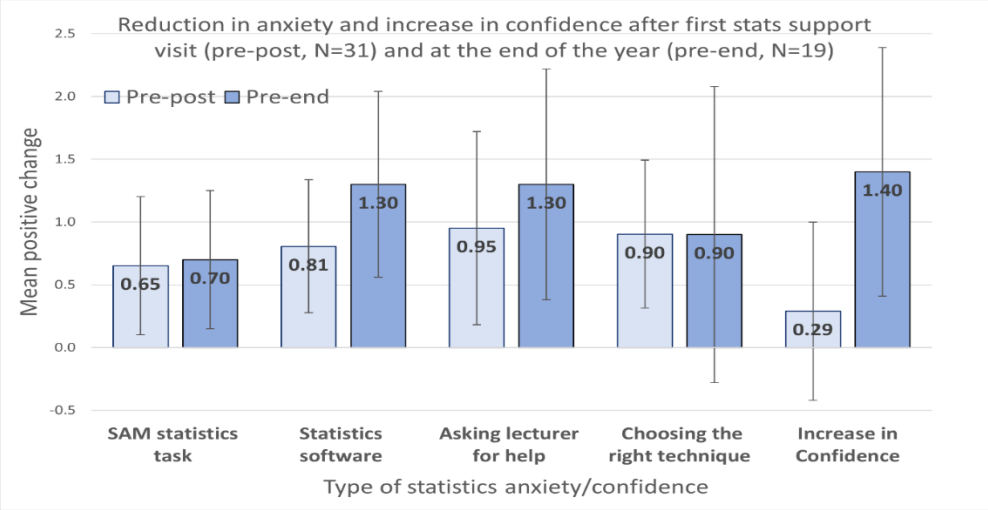

Fig. 2 The mean paired reduction in each type of statistics anxiety and increase in confidence (with 95% CI) from before a first statistics support session (pre) to either straight after the session (post) or the end of year

To compare the change in anxiety after one session for online and face to face sessions, MANCOVA was used to control for levels of anxiety prior to using statistics support. Although students attending

face to face sessions consistently had a greater mean reduction after controlling for pre session anxiety (Fig. 3), particularly for anxiety about choosing the right test and asking lecturers for help, the overall test was not significant, [F(5,15)=1.1, p=0.397, Wilk's Lambda=0.73, partial η^2=0.27]. However, the effect size suggests that further investigation with larger sample sizes could be worthwhile to determine if face to face sessions have a greater impact on anxiety reduction.

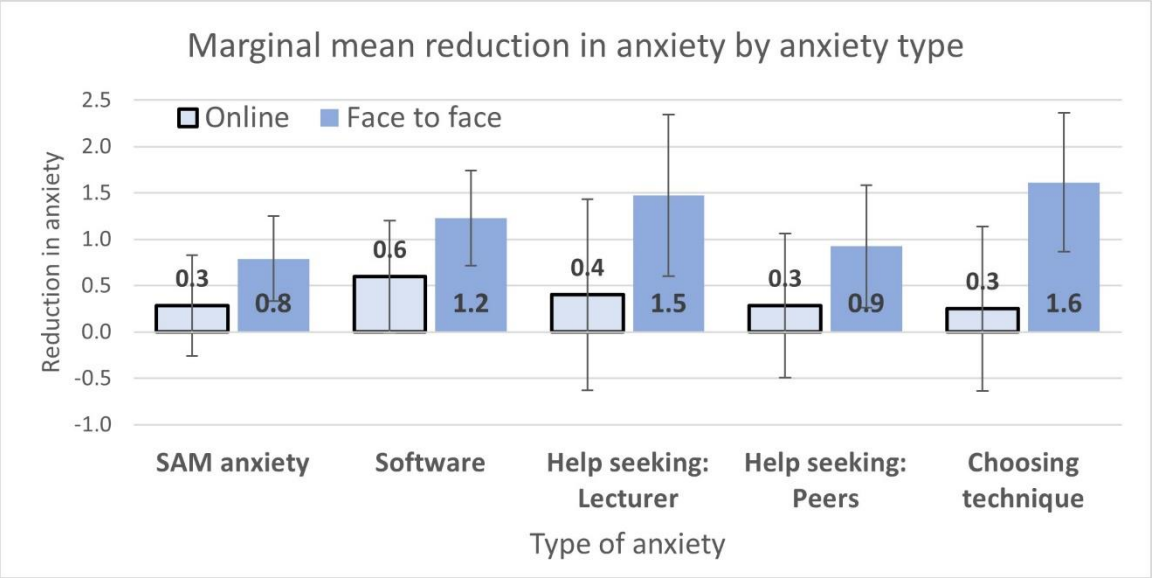

Fig 3. Marginal means from MANCOVA for change in anxiety by first appointment type

In the end of year survey, in addition to the lecturer help seeking items, there were the same questions relating to statistics support staff so comparisons between asking lecturers and support staff could be made. Even though the earlier t-tests suggest that students reduced their anxiety around asking lecturers for help (Fig. 2), a paired t-test on 91 responses showed that students still had significantly lower anxiety when asking for help in statistics support [t(90)=4.5, p <0.001], with a mean difference of 0.64 [95% CI: 0.36, 0.94].

4.2.2. Student perceived change in anxiety and confidence

All students taking the post (N=83) and end of year survey (N=102) were asked whether using statistics support had impacted on any anxiety or confidence with the topic they came in for help with and statistics generally on 5 point scales ranging from a lot less to a lot more (Appendix A). All students were included in analysis regardless of how anxious they were prior to the session and those reporting feeling more anxious or no change combined in the percentages displayed in Fig.s 4a and b. The majority of respondents choosing no change were students who had low levels of anxiety as measured by the scales. For reduction in anxiety, the most common response was that they felt a lot less anxious (Fig. 4a), whereas for confidence, it was a little more confident (Fig. 4b). Students reported this change regarding statistics generally as well as the topics they asked for help with, although fewer felt a lot less anxious about statistics generally after just one session (Fig. 4).

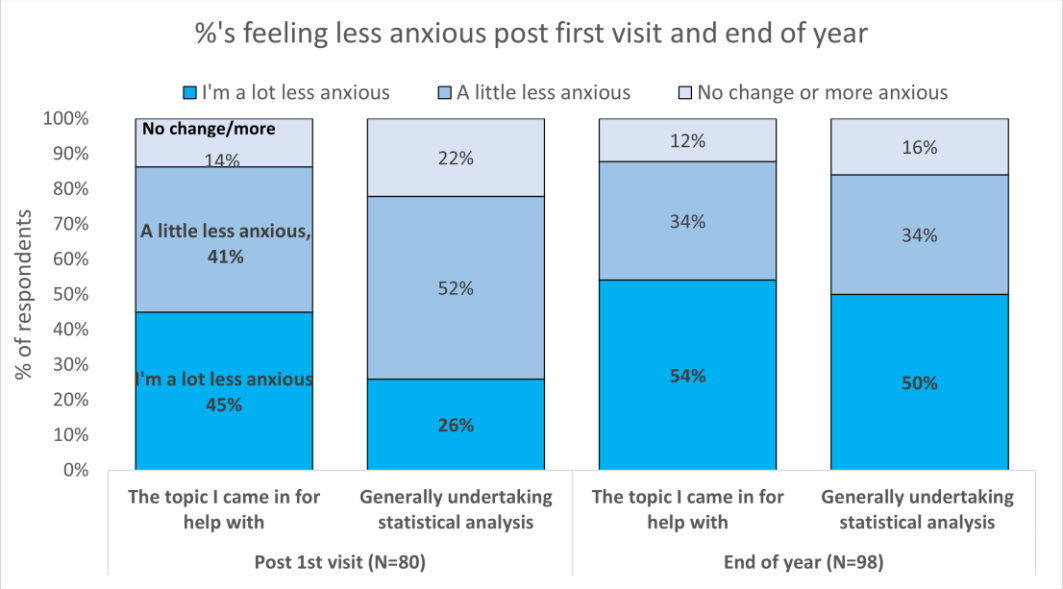

Fig. 4a: % perceived change in anxiety post first session and end of year

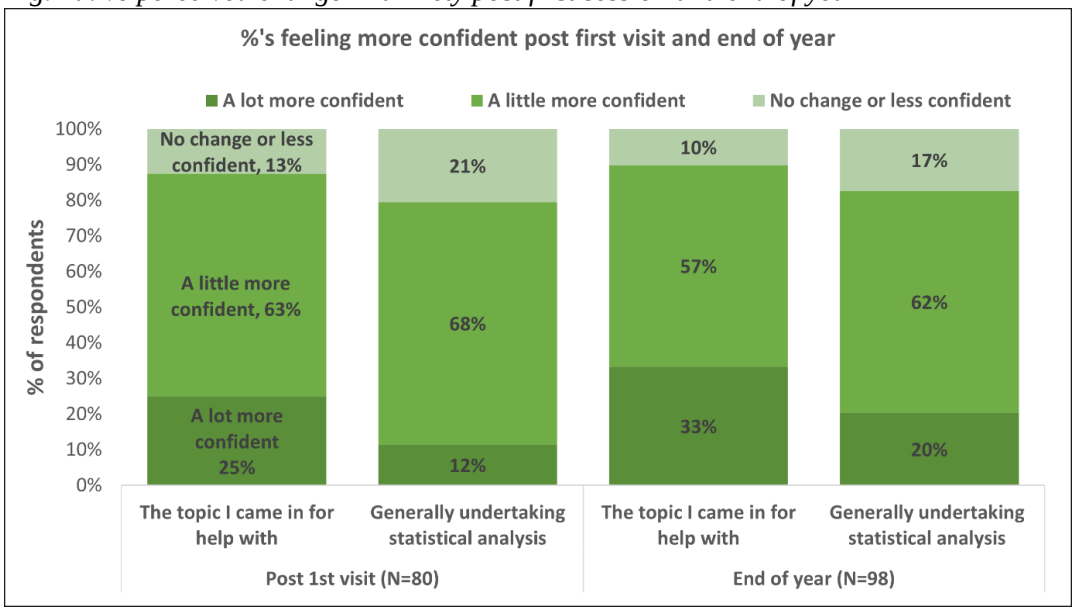

Fig. 4b: % perceived change in confidence post first session and end of year

Although a higher percentage of students attending face to face sessions reported feeling a lot less anxious than those attending online sessions, particularly regarding statistics generally (38% compared to 19%), Chi-squared tests on the three categories were not significant for the topic (p=0.479) or statistics generally (p=0.22). There were no differences between online and face to face for perceived change in confidence.

In the end of year survey, students were asked about their change in anxiety and confidence as a result of using statistics support for three additional areas of statistics (using software, interpretation of results, reporting statistical results) and the mean of each set of five items was taken to represent a general change in anxiety or confidence with statistics (Cronbach's alpha 0.93 and 0.88 respectively). Positive values indicate that students felt less anxious and negative values more anxious (2 represents a lot less anxious and –2 represents feeling a lot more anxious). Overall, the mean change in anxiety was 1.26 [95% CI: 1.11,1.4] with 88% of students reporting some reduction in anxiety. Similarly,

positive values for confidence indicate feeling more confident, and 91% of students reported a positive impact of confidence with a mean change of 1 [95% CI:0.86, 1.14].

Of the students who completed the end of year survey, 30 had used the service once, 28 twice and 36 three or more times. A one-way ANOVA with Tukey post hoc tests showed a significant difference for anxiety reduction [$F(2,90)=5.57$, $p=0.009$, partial $\eta^2 =0.11$] with a significantly higher change for those attending 3 or more sessions compared to those visiting once ($p=0.031$) or twice ($p=0.009$). Students who attended three or more times reported a higher reduction in anxiety on average (1.6) compared with those who attended once (1.1) or twice (1.0). Increase in confidence with statistics was similar for the number of visits with no significant differences found [$F(2,90)=0.34$, $p=0.27$, partial $\eta^2 =0.008$].

4.2.3. Preferences for online or face to face sessions

During the pandemic, questions on preferences for online or face to face were added including an open response question to explain any preference. Of the 70 students recording a preference, 63% preferred face to face, 23% preferred online and 14% had no preference, with a higher proportion preferring face to face from 2021/22 onwards compared with 2020/21. Convenience was the main driver for online preference with several mentioning being part time, work commitments or not living near the University. Comments explaining why students felt face to face was preferable centred around ease of communication, being able to point to things when next to the tutor, support seeming more personal and issues with online connections.

'*With face-to-face tutors can see your confused/understanding expressions, it also helps with listening when the person is right in front of you and can easily point and draw diagrams…*'

'*I feel like it is easier to work collaboratively in-person, as you can both look at the same data set and technical difficulties do not interfere with communication'*

'I preferred online sessions as I was a distance learning student and I am currently working full time whilst doing my MSc but if I was local I wouldn't have minded face to face sessions'

Spearman's correlations were used to assess whether anxious students were more likely to prefer online or face to face sessions. The general trend was for more anxious students to have a greater preference for face to face with statistical task anxiety ($r=0.29$, $p=0.018$) and anxiety around asking students ($r=0.34$, $p=0.006$), lecturers ($r=0.26$, $p=0.041$) or statistics support staff ($r=0.23$, $p=0.07$) for help, most strongly related.

4.3. *What are the benefits of statistics support from the student perspective?*

In the 2022/23 academic year, 34 students working on dissertations were asked how much they agreed with statements relating to taught statistics content and supervisors on a 7 point scale. These were correlated with the mean perceived levels of anxiety and confidence before using statistics support (Table 3).

Worryingly, not many students felt the statistics teaching on their course had adequately prepared them or felt that their supervisor was able to help with the statistical elements of their dissertation. The significant Spearman's correlations between the means of students perceived pre session anxiety and confidence levels and the responses to these questions showed that generally students with a lack of prior teaching or quantitative supervisory support had higher levels of anxiety and lower levels of confidence before using statistics support. Students were also asked if they would have been interested in attending additional basic workshops on questionnaire design, basic software, basic statistics and choosing the right test if they had been offered, with three options, No, Possibly and

Definitely. At least 80% of students would have been potentially interested in each workshop with 65% and 82% being definitely interested in basic statistics and choosing the right test respectively.

	Summary of 7 point scale			Spearman's correlations (r)	
	Disagree (Somewhat - Strongly)	Neutral	Agree (Somewhat - Strongly)	Perceived pre-support anxiety mean	Perceived pre-support confidence mean
The statistics teaching on my course adequately prepared me for my dissertation	58%	11%	31%	-0.39*	0.43**
My supervisor was able to help me with choosing and using suitable statistical analysis	44%	28%	28%	-0.3	0.36*
My supervisor was able to help me with statistical software such as SPSS or Jamovi	58%	17%	25%	-0.36*	0.40*

Table 3: Summary of responses for course teaching and support and correlations with perceived anxiety and confidence

These results suggest that staff in support centres are providing teaching rather than additional support for a large number of students, reinforcing the points made in Lawson et al. (2020) regarding a lack of staff able to teach quantitative skills and gaps in student statistical literacy and partly explains higher levels of statistics anxiety surrounding quantitative research.

It is important to note when interpreting results, that the post data was predominantly collected in one institution where only eight students did not see one of the authors of the paper, an experienced statistics support advisor. As previous literature has suggested, the quality of the staff (Finlayson, 2014) and learning environment are important (Lawson et al., 2003). Students were also asked questions about the support they received with responses ranging from strongly disagree to strongly agree and which tutors they had seen. Overall, 90% of students taking the end of year survey felt that the tutor was able to answer their questions, 89% agreed that the tutor explained at the right level and 95% felt comfortable asking questions in statistics support with higher scores for the main tutor and a greater change in anxiety. Further work looking at differences between tutors with a larger sample size is recommended.

In order to further explain why students felt statistics support was beneficial, the responses to open ended questions within the study were analysed. The qualitative comments from two open questions on how statistics support has impacted on learning, anxiety and confidence and general comments on how statistics support differs from other teaching gave five main themes.

Confidently making sense of and interpreting statistics

The most frequent benefit in the comments was how attending statistics support meant a student could make sense of statistics or understand how to interpret statistical results. This could be for exams, '*Statistics support help me make sense of the course materials to prepare me for the exam*' or final year projects '*...helped explain what the output meant and the relevance it had to my study…*'.

Respondents were prompted in the questions to think about confidence and anxiety. There were many instances in the comments where students directly attributed gaining confidence or experiencing a decrease in anxiety, after being shown how to make sense of statistics.

'*My confidence in interpreting the results has increased…*'

'*...she talked me through interpreting the results and what they mean. I feel so much more confident now…'*

'They helped me make sense of my notes and tackle my anxiety.'

Having choices of tests or understanding confirmed

Rather than seeking out new knowledge, another theme of several comments was about having existing knowledge, choices or interpretation of analyses confirmed. Phrases such as '*double check*' or '*second opinion*' indicated that students suspected they had the right answer but were using statistics support because they felt uncertain.

'*…it was useful to have clarification that I was on the right track…*'

As with the previous theme of making sense of statistics, comments concerning choice of test or having work confirmed were given credit for increasing confidence and reducing anxiety.

'*...made me less anxious to know that the analyses I had done so far had been done in the correct way.*'

'*The service gave me confidence in my own ability to pick the right test and design for my study, as the team confirmed it was the right approach!*'

While increasing confidence and reducing anxiety are desirable outcomes, one student's comments highlighted that this may not always be positive in terms of students taking ownership and responsibility for the quality of their own work.

'*The fact that an expert verified the testing methodology took the responsibility away from me.*'

Having specific questions answered

Another benefit that was frequently commented upon was the opportunity during statistics support to ask questions that the students felt were not generic or were only applicable to them.

'*Statistics support is far more personal and tailored to your specific problems*'

This benefit arises because many students attend statistics support while analysing data for their final year project. Each project is unique to the student and therefore the data is likely to be different to class examples or the work of peers.

'*...I could ask questions about my own work*'

This theme, although about questions, was quite separate to the theme presented below about feeling uneasy asking questions.

Avoiding the embarrassment of asking questions

Perhaps unsurprisingly considering respondents were a subset of students who had chosen to attend an MSC, they perceived the social judgement of asking questions to be lower in statistics support compared to tutorials or lectures. Some comments implied it was the opinions of other students that prevented them asking questions.

'*…it is easier to ask questions and get help, especially if you think the questions are a bit basic, and others will be bored or scoff at you if you ask for help.*'

'*It was easier to ask questions I felt were silly to others.*'

'*I could ask questions about my own work away from the class without being embarrassed about asking a silly question*'

In other comments it wasn't clear whether the judgement of students, lecturers or both was feared

'*...you can ask anything without feeling dumb about it*'

'*...helped me feel comfortable to ask questions that I was too afraid to ask in seminars/lectures*.'

Only one student explicitly said it was their statistics lecturer that they did not want to ask but the reason given was more to do with the student's circumstances during the Covid-19 pandemic rather than the behaviour of the lecturer.

'I felt awkward about asking lecturers the same questions - as I was supposed to know this information through their teaching and materials - however this was difficult to interpret having missed the sessions.'

The statistics in their courses

Some students thought content had not been covered in their course '*We had a research module to prepare for dissertation but it did not cover statistics at all.*' or that support was not available on their course '*...there's been no statistics support from the [name of department] in my other modules.'*. One student commented on the time lag between teaching and applying statistics '*The research methods module during first year is when we learned the majority of the statistics testing principles. It was hard to then remember these teachings during third year for the dissertation.*'

5. Conclusions, discussion and limitations

Given the lack of literature relating specifically to statistics support, this study set out to evaluate the effectiveness of statistics support quantitatively and qualitatively with a particular focus on statistics anxiety. The paper combines an in-depth literature review using existing research from mathematics support and teaching of statistics with the findings of this study to better understand how and why statistics support is effective.

O'Sullivan et al. (2014) found that anxiety was one of the main reasons for non-engagement with mathematics support but like Gokhool et al. (2022) who found that highly mathematics anxious student users were engaging, this study has shown that many students engaging with statistics support have moderate – high levels of statistics anxiety relating to undertaking statistical tasks, choosing the right test and statistical software particularly at Sheffield Hallam. Students from the University of York had significantly lower levels of anxiety than those at Sheffield Hallam but whether this is due to students generally having lower levels of anxiety or a lack of engagement by anxious students is unknown. Students undertaking research projects are more likely to be intrinsically motivated to learn and understand statistics so despite being anxious, more likely to engage in effective learning behaviours including help seeking.

This study also showed that many students felt they were inadequately prepared for quantitative research during their course, that their supervisors could not offer support with statistics. This lack of support was associated with higher levels of anxiety and lower levels of confidence. These findings, and the large number of students interested in additional workshops, add weight to arguments in Lawson et al. (2020) and Lawson et al. (2003) that quantitative skills of supervisors and students are lacking and that perhaps departments are relying on statistics support to provide teaching rather than additional support.

Considering the results of both the measured and perceived changes in anxiety and confidence we can conclude that statistics support can have a positive effect on students' anxiety and confidence. This

conclusion is supported by the student comments concerning decreases in anxiety and increases in confidence. This study is the first to assess the impact of mathematics or statistics support on anxiety and shows that most students report feeling less anxious after one session of support and that there is a longer term effect. The results compared between two time points show significant positive changes in the short and long term for SAM statistics task anxiety, statistics software anxiety and asking lecturer for help anxiety, and a short-term reduction in anxiety about choosing the right technique. Although students still had significantly lower anxiety about asking statistics support staff for help than lecturers at the end of the year, the significant reduction in anxiety asking lecturers for help suggests students may feel more comfortable approaching academic staff after using support. In line with previous literature relating to mathematics teaching or support (Woodard 2004; Jackson & Leffingwell, 1999; Carroll & Gill, 2012; Dzator & Dzator, 2018 and Ni Fhloinn et al., 2014), students felt more comfortable asking questions without fear of looking stupid, felt statistics support was more tailored to their needs and found immediate feedback or clarification about their work built confidence and reduced anxiety. Considering the thematic analysis, it is possible that the anxiety related to asking lecturers for help has more to do with social judgement and opinions of other students than the behaviour of the lecturer. The setting of MSCs is such that it is easier for students to ask statistics support staff questions one-on-one, as compared with the setting within which they would ask lecturers for help, which would generally be within the classroom.

Previous studies have been limited to measuring percentages of students that felt more confident in their general mathematics ability at the end of the year (Ni Fhloinn et al, 2014; Carroll & Gill, 2015; Dzator & Dzator, 2018) but Wilkins (2015) showed a significant increase in confidence about the topic students came in for immediately after one session. The current study uses perceived measurements and scales measured at two time points to show that whilst most students perceive that they are more confident, the measurements using scales on show an increase between before the session and at the end of the year. Students self-efficacy may increase slightly with immediate feedback (verbal persuasion) from a tutor but by the end of the year they may have submitted work or reached an achievement goal which has a larger impact on self-efficacy (Warwick, 2008).

Attributing decreases in anxiety and increases in confidence to visits to statistics support is naturally easier in the short term than the long term, since other factors are more likely to influence long term changes (MacGillivray & Croft, 2011), such as more practice using software or more time to become used to the material. However, the end-of-year results showing that students' perceived positive changes are similar to those post first visit support the hypothesis that visiting statistics support can have a sustained positive effect on anxiety and confidence. The thematic analysis provided in Section 4.3 also supports this hypothesis, since students commented on the positive impact statistics support had on their anxiety and confidence, and all responses were provided in the end-of-year questionnaire.

Positive instructor communicative behaviours have been shown to reduce anxiety and confidence when learning statistics (Williams, 2010; Tonsing, 2018), along with providing a non-threatening environment where students feel comfortable answering questions (Lalayants, 2012) and individual support outside the classroom (Wilson, 1999; McGrath et al., 2015). Immediacy behaviours and building emotional rapport is easier in a support setting, but it was anticipated that in an online setting, particularly if cameras are off, that some non-verbal communicative behaviours in particular may be lost. Although the descriptive results suggest that students attending online sessions may have higher levels of pre-session anxiety particularly for drop in sessions and have less of a reduction in anxiety and are less likely to report feeling a lot less anxious, there were no significant differences between online and face to face sessions. The effect size for the reduction in anxiety was moderate, suggesting further research with a higher sample size is warranted. The majority of students had a preference for face to face rather than online support and correlations suggest that this is particularly true for those with higher levels of help seeking and task anxiety.

For questions on perceived reduction in anxiety or increase in confidence, not all students had completed the pre-session survey, so those with low anxiety or high confidence prior to visiting statistics support cannot easily be excluded when assessing change. Therefore, anxiety reduction and increases in confidence are likely to be higher in students who are more anxious or less confident. Another limitation of the study is that the majority of students had seen one of the authors of the paper who are experienced and have an awareness of anxiety about statistics. Further work assessing whether these findings hold for different tutors and identifying the aspects of tutoring most conducive to reducing anxiety would be beneficial.

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LIST OF FIGURES

TABLES

Appendix A: Questionnaire

All statistics anxiety questions used a 7-point scale from 1 = Not at all anxious to 7 = Extremely anxious. Questions are taken directly or adapted from the statistical anxiety measure (SAM, Earp, 2007) and Statistics Anxiety Rating scale (STARS) created by Cruise, Cash and Bolton (1985).

General statistics task anxiety	Cronbach's	Pre	Post	End of year
Statistical anxiety measure (Earp, 2007)	0.917	√	√	√
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		√	√	√
Explaining your statistical findings		√	√	√
Software anxiety (adapted from SAM/STARS)	0.911			
Inputting/manipulating data in statistical software		√	√	√
Using statistical software to carry out analyses		√	√	√
Summarising results from the statistical software output		√	√	√
Choosing the right statistical technique (STARS)		√	√	√

As the SAM scale does not have a help seeking element, the STARS subscale for help seeking was used. There are four items in the original subscale but one was not appropriate for students taking the surveys so just the lecturer and student help seeking items were used.

Help seeking anxiety items	CA	Pre	Post	End
Fear of asking lecturer for help (STARS)	0.939			
Going to my statistics lecturer for help with material I am having difficulty understanding		√	√	√
Asking a statistics lecturer for help understanding computer output		√	√	√
Asking a fellow student for help in understanding statistics material (STARS)		√	√	√
Fear of asking stats support staff for help (adapted from STARS)	0.978			
Going to statistics support for help with material I am having difficulty understanding			√	√
Asking statistics support staff for help understanding computer output			√	√

Confidence with statistics was measured through agreement with 'I feel confident ……' on a 7-point Strongly disagree – strongly agree scale.

I feel confident ……	Cronbach's	Pre	Post	End
Choosing the right statistical test		√	√	√
Interpreting results from statistical software		√	√	√
Using statistical software		√	√	√
Writing statistical reports		√	√	√
Overall confidence scale mean	0.91			

Perceived change in anxiety and confidence.

In order to evaluate the students perceived change in anxiety, students were asked 'How has using statistics support impacted on any anxiety with statistics' and 'How has using statistics support impacted on your confidence with statistics' in a number of scenarios.

Each set were given 5 options and responses coded so that positive numbers indicate a positive change. For the end of year survey, mean change from the 5 items was calculated.

A lot less anxious	**A little less anxious**	**No change**	**A little more anxious**	**A lot more anxious**
2	1	0	-1	-2

How has using stats support impacted on any **anxiety** you had about statistics	Cronbach's	Pre	Post	End
The topic I came in for help with			√	√
Generally undertaking statistical analysis			√	√
Using statistical software				√
Interpretation of results				√
Reporting statistical analysis				√
End of year reduction in anxiety 5 item mean	0.92			

'How has using statistics support impacted on your confidence with statistics'

A lot less confident	**A little less confident**	**No change**	**A little more confident**	**A lot more confident**
-2	-1	0	1	2

How has using stats support impacted on your **confidence** with statistics?	Cronbach's	Pre	Post	End
The topic I came in for help with			√	√
Generally undertaking statistical analysis			√	√
Using statistical software				√
Interpretation of results				√
Choosing the right test				√
End of year increase in confidence 5 item mean	0.88			