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Mathematics and Statistics Support in the New Normal

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Mathematics and Statistics Support in the New Normal

By

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Mathematics and Statistics Support in the New Normal

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Certificate of Ethical Approval

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This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as High Risk

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Dedication

"Go back to basics"

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Research outputs

Publications

- Gilbert, H., Hodds, M., & Lawson, D. (2021). 'Everyone seems to be agreeing at the minute that face-to-face is the way forward': Practitioners' perspectives on post-pandemic mathematics and statistics support. *Teaching Mathematics and its Applications, 40*(4), 296-316. https://doi.org/10.1093/teamat/hrab019

- Gilbert, H. (2022). Changes with time of practitioners' opinions of online mathematics and statistics support. *MSOR Connections (Online), 20*(1), 37-45. https://doi.org/10.21100/msor.v20i1.1318

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Presentations

- Online presentation for **sigma** Network workshop: "One year on, what have we learned?" (Hosted by Coventry University) – 21st May 2021 – *"Investigating the change in Mathematics and Statistics Support due to Covid-19"*

- Online presentation for Horizons in STEM Higher Education 2021 conference (Hosted by the Open University) – 29th June 2021 – *"Online Mathematics and Statistics Support and their continuation post-pandemic"*

- Presentation at CETL MSOR 2021 conference (Hosted by Coventry University) – 2nd – 3rd September 2021 – "*Changes with time of Practitioners' opinions of online Mathematics and Statistics Support*"

- Online presentation for TALMO Workshop: Restarting the New Normal 2022 – 9th February 2022 – *'Everyone seems to be agreeing at the minute that face-to-face is the way forward': practitioners' perspectives on post-pandemic mathematics and statistics support"*

- Research Poster for Coventry University's COVID-19 Research Poster Showcase – 20th June 2022

- Online presentation for **sigma** Network's workshop: "The new normal: What does maths and stats support and teaching look like post pandemic?" (Hosted by the Open University) – 1st December 2022 – "MSS in the 'New Normal': *The practitioner and student perspective*"

- Presentation at CETL MSOR 2022 conference (Hosted by University of Dundee) – 1st – 2nd September 2022 – "*Barriers to engagement: The student perspective of Mathematics and Statistics Support"*

- Two presentations at CETL MSOR 2023 conference (Hosted by Cardiff University) – 7th – 8th September 2023 – *"In-person maths and stats support is much better than online, isn't it?", "'If the service was not only promoted, but promoted that it was okay to not understand': Is it time for a change in the way we advertise mathematics and statistics support?"*

Abstract

The global COVID-19 pandemic saw the unprecedented physical closure of all levels of educational institutions, requiring teaching to adapt to a fully online setting so that it could continue. As an established part of the infrastructure of many higher education institutions in the UK and across the world, Mathematics and Statistics Support (MSS) was no exception. As institutions had offered limited online support prior to the pandemic, the transition was mostly unprepared for. The additional help outside of regular degree structure that MSS provides can be a lifeline for some students. Yet student engagement has been an ongoing issue for many institutions, even before the pandemic caused a drastic decrease. Therefore, it is important to explore online provision and its effectiveness in comparison to before the pandemic.

This research study is a mixed methods three-phase investigation which aimed to contribute valuable insights into the influence of the global COVID-19 pandemic on MSS and its effectiveness at institutions both in and outside of the UK. Phase one was a longitudinal exploration into how provision, and the opinion of those who provide it, had changed since the pandemic began. Phase two looked at those for whom MSS is provided, both users and non-users, with a focus on barriers to engagement. Finally, a comparison of the pedagogy of online support to that of in-person was the focus of Phase three. Methodology included questionnaires, interviews, focus groups and observations, with both quantitative and qualitative data collected. Ultimately, findings from each phase informed a framework of recommendations for good practice of MSS in our new normal, suggesting potential solutions to discovered barriers.

MSS practitioners' pre-existing biases and general disbelief of the possibility of online support decreased after supplying online provision, to the point where the majority wished to keep providing some form of online support. However, a clear preference for in-person support remains amongst both practitioners and students, although the benefits online support has to offer are now more recognised and valued, with some students even preferring online provision. Accessibility and flexibility were constantly held in the highest regard by both practitioners and students, but technological issues are still being faced which is impacting the success and therefore opinion of online support. Evidence was found suggesting practitioners slightly adapt their pedagogical practice tutoring in an online setting, however this may not be as substantial as what was thought prior to the pandemic.

Key findings highlight the necessity of maintaining some form of online support alongside in-person provision, particularly for certain student groups. However, there is a needed shift in the frequency and focus of advertising, broadcasted in a way that challenges common misconceptions, emphasizing that it is okay to need help. A significant change could promote more engagement from students or highlight that there are other more affective reasons for non-engagement.

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1 Introduction

This thesis aimed to provide recommendations for the good practice of Mathematics and Statistics Support (MSS) in a post-pandemic society. These were informed by key findings from a mixed methods multiphase exploration, investigating the provision, provider and user opinion, and pedagogy of online MSS provision, since the unprecedented adaptation to online delivery due to the global COVID-19 pandemic. Both national and international perspectives were gained.

This chapter begins with a brief background of the field in which this research study is situated, before providing a summary of the study as whole and the addressed research questions. Finally, Section 1.3 details a brief description of what each chapter of this thesis covers.

1.1 Background

Mathematics and statistics support is additional optional assistance outside of regular degree structure in any area of mathematics and statistics, regardless of what discipline is being studied. It was introduced into UK Higher Education institutions as a response to increasing drop-out rates caused by undergraduates becoming increasingly unprepared to handle the mathematical material of their degree disciplines (LMS et al., 1995, Dearing, 1996). This phenomenon was due to reasons such as: increased mathematical content of traditionally non-mathematical subjects; an increased recognition of the importance of mathematical skills in society; and a decrease in students' ability compared to prior years (Lawson, 2003a; Kyffin & Panëels, 2011).

MSS is now an established part of university infrastructure within many institutions across the world (MacGillivray, 2009 [Australia], Cronin et al, 2016 [Ireland], Grove et al., 2020 [UK], Schürmann et al, 2021 [Germany], Johns & Mills, 2021 [USA]), most commonly offered in the form of in-person one-to-one drop-in services or pre-booked appointments (Lawson et al., 2020). The one-to-one nature of interactions between tutors and students during MSS, unlike traditional lectures, is of great importance as it allows the tuition to be tailored to the students' individual needs, unachievable when lecturing to hundreds of students. The service differs between institutions depending on what is available to them, from having a dedicated independent centre, to offered as office drop-ins; or provided by specialised dedicated MSS staff, to undergraduate students working part-time (Mac an Bhaird & Lawson, 2012, Matthews et al., 2013). This support can be a lifeline for some students, yet it has regularly been reported that there are students who are not engaging with support but would benefit from doing so (see for example, Symonds et al., 2008, Matthews et al., 2013, and Gokhool, 2023).

As a result of the global COVID-19 pandemic, education at all levels was forced to transition rapidly to online provision. Although there was online learning within Higher Education prior to the pandemic, face-to-face methods were a lot more prevalent, and any online learning methods that were available tended to be asynchronous, such as emails, discussion boards, and videos (Siegel et al., 2021, Jisc Data

analytics, 2023). Hence the adaptation to online synchronous delivery was unprecedented for many, and MSS was no exception.

Advantages and disadvantages of online learning had been reported prior to the pandemic (see for example, Bennett & Lockyer, 2004, Lloyd et al., 2012, Dumford & Miller, 2018). However, it was found that external influences of the pandemic were heightening them, particularly the loss of interaction (Rapanta et al., 2021). Some disciplines also faced unique obstacles with the move, particularly mathematics, having factors such as mathematical notation, mathematics anxiety, and collaborative problem solving to consider in a digital setting (Karal et al, 2015, Daneshamooz et al., 2012, Trenholm & Pesche, 2020). This left many feeling that mathematics is more challenging to teach in an online setting (Trenholm & Pesche, 2020). Due to the nature of the interactions between tutors and students in MSS, these elements may occur more than they would in a 'standard' mathematics lecture, and hence, maybe due to these preconceptions, prior to the pandemic little to no online support was offered by institutions. Often, the only online MSS provision at an institution was a website that provided resources or information about the in-person support that was offered (Hodds, 2020a, Mac an Bhaird et al., 2020a).

Before COVID-19, there had been some surveys of provision of MSS (for example, Cronin et al., 2016, Ahmed et al, 2018, Grove et al, 2020), but if online provision was mentioned it was often only brief, most likely due to the little provision on offer. Research at the height of the pandemic focused mainly on the transition from in-person to online delivery, focusing on sharing experience of what institutions were providing. Opinions from the practitioners responsible for those changes were somewhat explored, discussing predictions for the future of online MSS, but there has been limited research offering a follow up to compare actuality. As a result of this focus, student opinion of online MSS has rarely been reported since the outbreak. Hence this thesis aims to provide valuable wider-scope insights into these identified gaps.

1.2   Research aims

This PhD study had been broken up into three key phases of exploration into MSS: the practitioner perspective, the student perspective (with a focus on barriers to engagement), and the pedagogy of in-person versus online support. MSS provision, together with opinions of such services from users, non-users, and providers, were collated from institutions both in and outside of the UK, prior to, during and 'post' the COVID-19 pandemic, to discover how they matured over time. Together with observations of pedagogy, key findings from each phase of this study were used to form a framework of informed recommendations for good practice in the provision of MSS in 'the new normal'. These include preferred methods of support and to what extent they should be offered, student engagement and how to overcome the barriers preventing it, and an alternative look at advertising.

Hence, each phase of the study was focused on addressing the following research questions:

Phase 1 – **The Practitioner** **Perspective:**	**RQ1:** What mathematics and/or statistics support methods did institutions in the UK and the rest of the world offer ***prior to*** and ***during*** the pandemic? **RQ2:** What were the ***practitioner*** opinions of online MSS provision at the start of the pandemic and how did these change as the pandemic progressed?
Phase 2 – **The Student Perspective:**	**RQ3:** What is the ***student*** opinion of MSS provision and its effectiveness since the pandemic? **RQ4:** What are the current barriers to student engagement with MSS and what can institutions do to reduce these barriers?
Phase 3 – **Observation of Pedagogy:**	**RQ5:** Is there a significant difference in pedagogy based on whether MSS is delivered online or in-person and what influence, if any, does this have on students?
Overall aim:	**RQ6:** What constitutes good practice in MSS provision in the 'new normal'?

This research aims to contribute valuable insights into the influence of the global COVID-19 pandemic on MSS and its effectiveness. It both contributes answers to questions posed in the literature, such as why students are not engaging with MSS, while also exploring novel aspects such as the pedagogy of online versus in-person support. Multiple institutions both inside and outside of the UK were sampled to gain a wider and deep understanding so that this research, and the resultant recommendations of good practice in MSS, could be as beneficial to as many institutions providing MSS as possible.

1.3   Thesis outline

This introductory chapter has established what area of research this thesis falls into, providing a brief background of the research problem for the context of the study. It described the aims and questions that were addressed and explained why it is a valuable contribution to the field.

A thorough literature review, exploring the background of the research problem in more depth is provided in Chapter 2. It begins with a look at online learning within Higher Education and its perceived benefits and barriers by both students and educators. The focus then narrows to look at teaching mathematics online specifically, with emphasis on the unique challenges the discipline faces compared to other subject areas. Finally, research of MSS provision is then reviewed, both prior to and after the

pandemic began. Provision, opinion, and engagement are discussed, identifying gaps in the literature that this thesis aimed to provide a contribution towards.

Chapter 3 provides a foundational overview of the general methodology used in the study as a whole. It describes research approaches and data collection methods suitable in the context of the research, justifying any choices made for the methodology used in the three phases of exploration. Ethical considerations taken, an overview of quantitative and qualitative data analysis techniques that were performed, and general limitations of the research identified are also presented in this chapter.

The results chapters are four, five, and six for the practitioner exploration, the student exploration, and the observation of pedagogy respectively. Each chapter begins with an overview of the approach and why it was investigated, reiterating the specific research questions associated with that phase. The specific methodology and data analysis used is then described before presenting the results. A discussion of the key findings is then presented with a comparative look at other works in the topic area. Specific limitations for that phase are then identified and discussed before a final summary of the chapter.

Chapter 4 details a longitudinal study consisting of three sampling points over a 13-month period, looking into the thoughts and opinions of practitioners on the transition to online MSS, and the provision they offered. Chapter 5 follows a mixed methods approach to investigating the opinions of engagers and non-engagers of MSS, two years after the initial COVID-19 outbreak. It describes a two-part investigation: an initial study at Coventry University, and a second, larger scale study looking at institutions both inside and outside of the UK. The two parts were then combined to present a whole picture. Finally, Chapter 6 reports an observational study conducted at three UK universities observing how MSS tutors supported students in both online and in-person settings for a comparison.

Informed recommendations for good practice of MSS in the new normal are provided in Chapter 7, having brought together the key findings from the three previous chapters. A summary of the research study is provided for convenience, followed by a summary of the answers to the first five research questions. Recommendations are made in the areas of provision, student engagement and advertising, with a focus of overcoming identified barriers. Finally, suggestions of future work to build upon the conclusions made in this thesis are presented.

2 Literature Review

2.1 Introduction

Mathematics and Statistics support (MSS) was introduced in the UK by Higher Education (HE) institutions in the early 1990s, as a response to the rising phenomenon: 'the Mathematics problem' (LMS et al., 1995). This term describes undergraduates' increasing under-preparedness to handle the mathematical material of their degree disciplines, which was a result of a noticeable decline in students' mathematical ability compared to prior years (see, for example, LMS et al. (1995), Dearing (1996), Crowther et al. (1997)). This led to numerous problems, including an increase in dropout rates (Dearing, 1996, National Audit Office, 2007). Since the 1990s, the mathematical content of most disciplines has increased, further escalating the problem. Beyond the traditionally mathematically dependent disciplines (mathematics, physics, and engineering), subjects such as the social sciences, humanities, business, and health (Kyffin & Panëels 2011) now all contain significant amounts of mathematical and statistical content. There has also been a rapid increase of recognition of the importance of mathematical skills by employers (Kyffin & Panëels 2011), with many now requiring numeracy tests as part of the recruitment process, regardless of whether students have studied a degree containing mathematical content. MSS offers support to students outside of their regular degree structure (Lawson et al., 2003), helping them to cope with any under-preparedness, and is now an established part of the Higher education infrastructure (Lawson et al., 2020).

The year 2020 saw the event of a global pandemic, with over 100 countries worldwide initiating some form of lockdown measures (Dunford et al., 2020). These measures led to the physical closure of educational institutions at all levels. Educators immediately had to provide learning in an online setting, often using an adaptation of traditional pedagogical methods, to continue to provide their teaching. In common with all other aspects of education, MSS also had to respond to that rapid transition to online provision.

Prior to COVID-19, there had been some, but not substantial, reviews of provision of online MSS by institutions across the world. One reason for this is the number of institutions offering online support was very low up until the beginning of the pandemic, so obtaining opinions was therefore difficult (Cronin et al., 2016, Mac an Bhaird et al., 2020a, Hodds, 2020a). A website detailing information about the in-person services provided was often described as the main or even only online resource offered (Mac an Bhaird et al., 2020a), and hence the transition was sudden and un-prepared for.

This review begins by looking at the response to online learning within Higher Education and the benefits and barriers perceived by both students and educators. It explores the influence of the pandemic, evidence of investigation into overcoming the barriers and what online learning looks like now, post-pandemic. Teaching mathematics online specifically is then explored, particularly focusing on the unique challenges the discipline faces compared to other subject areas. Finally, MSS provision

is then focused on. Provision prior to the pandemic is discussed to then make comparisons with online provision during and 'post' the COVID-19 outbreak, where the response from students and practitioners and their thoughts on student engagement is explored.

2.2   Online Higher Education

Online education is the delivery of educational content via the internet. It is thought of as one of the main forms of distance education (Magd et al., 2023), which although it has multiple definitions, is generally considered to be structured learning where the student and instructor are physically distant from each other (Saykili, 2018).

Harasim (2000) states that university courses began being supplemented by e-mail and computer conferencing as early as the mid-1970s, and the first online university courses were offered from 1984. Online university courses then dramatically increased from the early 1990s (Wallace, 2003) to what we see today where online learning is now considered a new normal worldwide (Magd et al., 2023).

However, prior to the pandemic, teaching in HE institutions was mainly in-person. A large-scale study by Siegel et al. (2021) explored computer studies teaching before, during, and after the pandemic. They received 180 responses from institutions in 20 countries around the world, 161 of which stated they were from HE institutions. Prior to the pandemic, 49% taught fully in-person 100% of the time, with a further 34% doing so for 80% of the time. Asynchronous online learning methods, where teaching and learning are not occurring at the same time such as emails, pre-recorded lectures, supplementary material, and discussion boards, were more common than synchronous methods, such as live lectures over conferencing software. They found 87% of their respondents did not use any synchronous delivery. Additionally, in the Jisc Digital experience insights survey 2019/20, which surveyed 3,485 teaching staff in 26 UK higher institutions, 74% had never taught in a live online session (Jisc Data analytics, 2020). Therefore, when the pandemic hit, although online learning had been introduced to some institutions, for others it was new territory, particularly providing synchronous education.

Prior to the pandemic, there was already a debate on whether traditional teaching methods (for instance in-person lecture-based teaching) are still the most effective way of teaching (see for example Sondoozi, 2000, Emerson & MacKay, 2011, Anaga & Biney, 2017). Hence there have been multiple studies over the years that compare online and in-person teaching, particularly looking at benefits and drawbacks, and staff and student opinion. In February 2021, the Office for Students, the independent public body responsible for Higher Education sector in England, published an extensive report, *Gravity Assist*, reviewing digital learning and teaching in higher education (Barber et al., 2021). They likened their work, identifying important lessons learned during COVID-19, as a 'gravity assist' to the online learning sector (a metaphor comparing this report helping advancements in the sector, to when a spacecraft uses the gravitation pull of planets to propel itself further in space). The substantial review

was based on findings from a large-scale data collection via a 'call for evidence' receiving 200 responses, 52 interviews with a range of involved participants from students to digital learning experts, global polling of 1,284 students and 567 HE educators, and a review of previous literature. It is therefore a key source in the literature review presented here.

2.2.1 Benefits of online learning

Barber et al (2021) describe five categories into which the benefits of online learning can be placed. These are: increased flexibility, personalised learning, increased career opportunities, pedagogical opportunities, and global opportunities; these are explained further below. These advantages have been recognised both before and since the pandemic.

Increased flexibility

Online learning has the potential to reach more student groups. Since there are no constraints caused by having to secure a physical space (for example, a lecture theatre or classroom), online learning can be held for longer hours. Students also do not have to commute, thereby saving them time, and they can access the content at a time that suits them via technology at their home.

> *"...extra time was available to work on Math problems since everyday mobility was curtailed and commuting eliminated"* (Pilotti et al., 2022, p.7)

This can be particularly beneficial for less flexible students, like mature or disabled students who find it harder to get to campus, or students with busy schedules with other commitments like part-time jobs.

> *"Such flexibility allows students to work in different locations at different times and makes it easier for those incorporating study with other commitments..."* (Bennett & Lockyer, 2004, p.237*)*

> "*When asked why they chose to take online courses, almost all respondents* [community college students] *explained that they had busy lives with multiple responsibilities and that the flexibility of online learning helped them better balance their schedule*" (Jaggers, 2014, p.29*)*

This flexibility was obviously fully relied upon during the pandemic, as educational institutions were closed, and students had to continue their education from their homes. This could arguably be the most important advantage of online support as it allowed education to continue while pandemic restrictions were in place.

Personalised learning

The diversity of online learning tools (for example: videos, worksheets, recorded lectures, and forum discussions) offers students a choice of how they learn. Students can explore and utilise the types of

resource that best suit their learning style at their own pace. For example, aural learners can listen to recorded lectures or podcasts, visual learners can use graphics and watch videos of content in practice and kinaesthetic learners can use worksheets repeatedly or get involved with online discussion forums (Bonk & Zhang, 2006). Asynchronous resources also offer the chance to navigate at their own pace.

> *"The big advantage of using an asynchronous environment is that everyone can explore information at their own pace and react to it before hearing the views and interpretations of others"* (Salmon, 2013, p.27)

> *"Students have more control over learning materials; they may choose the appropriate access time, sequence, pace, and amount of information and may follow a more individualised approach"* (Li, 2022, p.2)

Due to this diversity of tools allowing students to create their own learning experience, online learning can cater to personal circumstances such as anxiety. Students who would usually struggle with the social anxiety of attending lectures in-person could utilise asynchronous resources, or attend lectures online without their cameras on, in the comfort of their own space. Jisc conducts a 'digital insights' survey every year looking at aspects of learning with digital technologies, including student opinion. In their most recent survey (at the time of writing) they included this anonymous quote from a respondent:

> *"As someone who suffers from social anxiety, I find it a lot easier to study online. I have also recently become a first-time mum so balancing my Master's while I'm off on maternity allows me to study at my own pace"* (Jisc Digital Analytics, 2023, p.14)

Increased career options

Many online learning resources are asynchronous, requiring students to use them actively and independently and so they learn to be proactive. Effective use of such resources also requires a different set of skills to in-person learning within a lecture theatre, for example, navigating webpages, online safety, software use and online etiquette, transferable skills for a digitalising world.

> *"...skills required for effective learning inside the virtual space are also transferable to prospective employment settings"* (Neuwirth et al. 2021, p,144)

Technology is also becoming more readily available and so usage is growing. For instance, in response to the pandemic, where possible, 'working from home' was established for employment settings. Since restrictions have lifted, now aware it is possible, this mode of working is still an option for many (Neuwirth et al., 2021). Hence, with the digitalisation of the world ever increasing, this will only offer greater opportunities for students, creating some positions that do not even exist yet.

"In a competitive and rapidly changing world, workforces need to be capable of continuously adapting to shifting job requirements and organisation procedures related to new skill-intensive technologies." (CEDEFOP, 2012, p.37)

"In future, today's pupils may be employed in roles that do not exist yet, and it is highly likely that strong digital and social-emotional skills will be needed to thrive." (Barber et al., 2021, p.34).

Additionally, the increased flexibility of online learning can allow adult learners in employment to update their knowledge and skills while maintaining their responsibilities, allowing for more opportunity to progress in their careers, or branch out into new ones (Park & Choi, 2009).

Pedagogical opportunities

Online, information can be presented more easily in an interactive way, like the use of online quizzes and games, interactive videos, or debates on discussion forums. Interactive activities can increase interest and engagement and therefore increase the chances of retention. This was observed for in-person teaching by Franklin et al., (2014), who found physics students taught with activity-based sessions retained knowledge to at least the end of the semester, compared to only three weeks amongst students taught using traditional lectures. This is an example of active learning, defined in general as instructional activities that get students doing things while encouraging them to think about what it is they are doing (Bonwell & Eison, 1991). Essential parts of active learning are students being engaged in meaningful activity that gets them involved in the learning process, as opposed to passively receiving information in a traditional lecture setting, as an example (Prince, 2004).

Additionally, newer technological advances such as Artificial Intelligence (AI) and Virtual Reality (VR) can offer opportunities that a physical classroom cannot (Barber et al., 2021). Experiments can be conducted in infinite space with equipment not accessible in-person, and virtual spaces can accommodate many more people in place of a crowded lecture hall with limited seating.

Global opportunities

Video conferencing software has now made connections with overseas partners more easily available, resulting in opportunities to access resources that were not there before, such as attendance at international conferences, opportunity for international research, and collaboration on studies with international perspectives. For example, Coventry Online International Learning (COIL) initiative, which began in 2015, allows students from different universities across the world to collaborate on projects, gaining cross-cultural perspectives and ideas, learning to communicate on a global scale before entering the workplace (see coventry.ac.uk/COIL). In the 2020/21 academic year, because of the lack of movement and travel due to the pandemic, COIL trebled it's reach (coventry.ac.uk/news/2021/coil/).

Further, 485,645 international students studied in the UK for Higher education during the academic year 2018/19, which made the UK the second most popular location for international students (Universities UK, 2018). With increased digitalisation, education outside of your home country becomes more accessible, reducing commutes and costs which in turn have their own benefits.

> *"...in the future, in the distance education programs there will be more international students most of whom will probably be still working but aim to improve themselves in various fields"* (İlin, 2019, p.14)

Overall, the five benefits discussed here all reflect a chance for greater opportunity, both for students and educators alike, ranging from students who had difficulties accessing education in-person now having learning opportunities readily available, to academics being able to present research at conferences attended by others from around the world, opening international collaboration possibilities.

However, although online learning has clearly identifiable benefits, it can also have its disadvantages.

2.2.2   Issues with online learning

2.2.2.1   *Before the pandemic*

There have been downsides to online learning identified in the literature prior to the pandemic, including three that are most commonly experienced: lack of interaction, both learning specific and general social exchange; technological issues, ranging from limitations of technology to not possessing necessary equipment; and simply a preference for face-to-face teaching. Advantages to some student groups can also have a negative impact on others. These are discussed in more detail below.

Lack of Interaction

As discussed earlier, many online learning materials are asynchronous, but even with live online lectures, the students are in separate locations and engaging via video conferencing software. This makes interaction and collaboration harder to achieve. A large-scale factor analysis survey, receiving 1,056 responses from American students, who took some form online learning course, identified "*the single most important*" barrier to students was lack of social interaction (Muilenberg & Berge, 2005).

> *"...students with and without experience with online courses seem to view online courses as lacking in interaction"* (Tichavsky, 2015, p.3)

> *"...first-year students who take more classes online report lower levels of collaborative learning in their courses, fewer diverse discussions with others, and lower quality of interactions*" (Dumford & Miller, 2018, p.7).

Educators are also impacted by loss of interaction. In a 2012 investigation into staff perceptions of online learning barriers, lack of personal relationships with students was the third highest ranked barrier below workload and time constraints (Lloyd et al., 2012). Regarding learning interaction specifically, educators can find it harder to assess the understanding and engagement of students in an online setting, due to the absence of key communication components, depending on the online learning method, such as body language and gesturing, tone of voice and immediacy (Dennen et al., 2007).

Lack of interaction can also be in a social context, particularly if the learning is only online. Interacting with peers in a social setting, feeling part of a community at university, can create a sense of belonging, which has been shown to help reduce drop-out rates (Wang et al., 2019). If learning is solely online, that community is harder to establish because you are separated by a screen in different locations.

Technological issues

It is to be expected that with an increase in use of technology, comes an increase in awareness of any problems that technology has, especially if that technology is at or near the leading edge. Problems include such things as internet connection, camera and microphone quality, software glitches and website crashes due to high activity.

Additionally, technology is an example of online learning benefiting some student groups but disadvantaging others. On the one hand, as stated in benefits, the use of technology at home can allow education to reach some students from whom it was previously inaccessible, for instance students who find it difficult to commute to campus. But on the other hand, increased use of technology may reduce access by other student groups previously engaged with learning, such as students from low-income households or those receiving education in areas with poor internet connectivity. These students and institutions may not have access to the required technology to begin with. In 2018, 700,000 11–18-year-olds in the UK did not have access to internet with a computer or tablet (Lloyds Bank UK, 2018), making it difficult to access and use online learning material.

The same applies to disabilities such as visual or hearing impairment, where recorded lectures and online resources are not possible to use without additional equipment like transcribers or screen readers. Similarly with learning difficulties like dyslexia, where required technology use, particularly reading and writing online, can enhance challenges already experienced with in-person learning.

> *"Their* [learners with dyslexia] *participation in this type of learning activity* [synchronous e-learning] *seems to contribute to an already established pattern of low self-esteem and low confidence in their ability to learn, and ultimately causing withdrawal*" (Woodfine et al., 2008, p.712).

Preference for face-to-face education

Regardless of any advantages reported, studies still found students preferring face-to-face education, suggesting there is still some element of in-person learning that online learning could just not currently offer. In 2010, Tichavsky et al. (2015) surveyed 730 undergraduate sociology students self-enrolled on a mix of in-person (n=360) and online (n=370) courses on their preference of course type and reasons for it. Just over half (56%) preferred face-to-face, 30% preferred a combination of face-to-face and online, and 13.6% preferred entirely online.

> "*My delivery method of preference for education is always face to face…to continually learn from the act of interaction with another human being. Learning with a class of people creates energy and a comradery* [sic] *that cannot be gained in any other format.*" (Tichavsky et al., 2015, p.3)

> "*...face-to-face instruction helped me understand the course concepts better. So, I preferred face to face sessions*" (Erdem & Kibar, 2014, p.203)

The three limitations discussed above were regularly identified prior to the pandemic, meaning it can firmly be concluded they were a result of online learning itself as opposed to outside factors. However, when online learning was forced to be the only source of education, these issues became more prevalent.

2.2.2.2 *Since the pandemic*

When learning is solely digital, as occurring during the pandemic, drawbacks may be exaggerated.

> "*...the emergency shift to online teaching overemphasised its remote qualities, arising from the need to avoid in-person interactions due to the pandemic restrictions*" (Rapanta et al., 2021, p.717)

In *Gravity Assist* (Barber et al, 2021), it is reported that 70% of 18–24-year-old students and 55% of over 35s stated they lost motivation to learn during the pandemic. The three issues described above in Section 2.2.2.1, may be able to partly explain this. However, it is important to remember that there will be other pandemic-related contributions, not connected to online learning, that are also influencing this lack of motivation to learn. In an interview conducted by Noori (2021) exploring the impact of COVID-19 on higher education students in Afghanistan, one student admitted how the pandemic affected him psychologically "*...I was worried psychologically for my health and future.*" (Noori, 2021, p.6). The pandemic created a great deal of fear and uncertainty of the future for people of all ages, particularly the health and lives of loved ones, so it is reasonable to understand why motivations were elsewhere.

Online fatigue and negative opinions towards online learning, as a result of burnout from all education being online, have been reported as an impact from pandemic measures (see Salim et al., 2022, and Patton & Tuke, 2022, as examples). Loh et al (2022) conducted a survey of 384 Malaysian university

students to investigate the influences of mobile learning via social media, which is online learning using a mobile device, such as a smartphone or tablet, via social media. They found a significantly positive relationship between the stress experienced when using technology, and feelings of exhaustion and boredom, concluding that students who experience stressful situations when mobile learning would become fatigued, leading to reduced usage. The online fatigue can reduce the uptake of online services, making it seem that the students prefer face-to-face, risking the removal of this provision and disadvantaging student groups that rely on online learning, for example, disabled students and mature students.

The UK is also now, at the time of writing, facing a cost-of-living crisis (see Harari et al., 2023), which will only exacerbate technological issues. The 2022/23 Jisc student digital experience and insights survey reported that of the 27,131 respondents, who were all students in UK higher education, 54% had poor Wi-Fi connections and 27% had no suitable device. They reported that these issues had become more of a problem since their survey the previous year, and that they are likely to become more severe with the growing cost of living (Jisc Digital Analytics, 2023).

Of the educators polled in *Gravity Assist,* over half (56%) agreed with the statement "*I would like to return to fully face-to-face teaching and learning as soon as possible*". Further, 29% of students chose the option *"Nothing – I do not think any aspect of my course should be delivered online after the pandemic"* when asked what part of their course they would they like to see continued digitally (Barber et al, 2021). During this period, findings like this were probably to be expected as the pre-pandemic norm of a traditional in-person lecture, has been in place for hundreds of years, dating back to the late middle ages (Norm Friesen, 2011). This well-established and trusted delivery form had suddenly, rapidly and unpreparedly (in most cases) been taken away.

During the pandemic, students lost not only the opportunities to interact with others at scheduled teaching events and the learning interaction between student and teacher, but also the entire social side of university which, in itself, can impact motivation and enjoyment of learning.

> *"...very little has been done to fulfil the myriad of opportunities provided by university life for entertainment, leadership, socialising, community engagement, etc."* (Gamage et al., 2020, p.5)

A common teaching method during the pandemic was synchronous online lectures using video conferencing software, and it was regularly reported that interaction loss was a result due to students not having their cameras on (for example, Hodds, 2020a, Banki, 2021). Cassibba et al. (2021) even found that 21% of their sample of 27 Sicilian mathematics professors stated they never turned their cameras on as they wanted the students to focus on the content. This shows that educators can also be affected by a want to stay hidden. This results in the absence of eye contact, body language and facial expressions; unspoken communication that can help teachers determine if the material is both engaging

and understandable. However, additionally in *Gravity Assist*, 23% of staff and 15% of students reported a lack of required equipment in the first place (Barber et al., 2021).

It is important to note here that these issues are not isolated to the UK. An example of a study that finds all three issues described in Section 2.2.2.1, is Rizvi and Nabi (2021). They used online interviews to explore the feelings of 40 Commerce Management specialist students from three Delhi and National Capital Region public universities, in the transition to online learning. The largest concern was connectivity, with 90% of students commenting on the issue. The writers state that only 23.9% of Indian households have access to the internet. This will clearly disadvantage students that were potentially previously engaged, as they no longer have access to learning. 15% of respondents commented on lack of communication and interaction, closely followed by fatigue and lack of motivation caused by extended screen-time, with 12.5%.

Survey	Number of Respondents	Quality of Online Learning (%)			Preference (%)		
		Below Average	Average	Above average	In-person	Online	Blended
2019/20	20,575	5	18	77			
2020/21	38,917	12	21	66			
2021/22	33,726	8	18	75	42	13	45
2022/23	27,131	5	15	79	53	11	36

Table 2.1 Jisc student digital experience insights survey data from academic years 2019/20 to 2022/23 (Jisc Data Analytics, 2020, 2021, 2022, 2023)

A preference for in-person learning is still present in 2023. Table 2.1 displays relevant survey data from the Jisc student digital experience insights survey for the past four years (the question regarding preference for mode of delivery was only introduced in the 2021/22 survey). In the most recent survey (at the time of writing), of the 27,131 student respondents, just over half (53%) still preferred mainly in-person teaching. However, as the height of the pandemic falls further into the past, new appreciation for online learning may be being seen. In the same survey, Jisc found that 79% of students rated online learning on their course as above average: good, excellent, or best imaginable, which was slightly higher than the highest value before the pandemic, 77% in the 2019/20 survey (Jisc Data analytics, 2020, 2023). Additionally, although they found an increase in preference for face-to-face teaching this year, in their 2021/22 survey of 33,726 students, blended leaning was the most preferred method of teaching (45%), slightly above on-site only (42%) (Jisc Data analytics, 2022). This suggests that the opinion of online learning we saw during the pandemic may have been exaggerated by external factors, however in-person teaching is likely still the preferred method.

2.2.2.3 *Overcoming barriers*

The pandemic forced educators to consider these drawbacks and either work around them or begin to think of how to overcome them.

Barber et al. (2021) stated that a key principle in planning online education is that how students learn should be the focus of the design. This then drives how technology is used, instead of attempting to replicate traditional teaching methods in an online environment by "bolting on" technology. This conclusion is actually the opposite to what was implemented during the initial 'crisis driven' transition to online. *"...video seminars, live and recorded online lectures, and lecture slides covered the bulk of digital teaching..."* (Barber et al., 2021, p.4), which are very similar methods to in-person teaching.

They recommend new methods should be designed with accessibility in mind; to reach the least accessible students first and then adjust for improvements. This would combat the technology issues and reach as many student groups as possible. Hence to achieve this, the authors stressed regularly that involving the student voice at every opportunity is crucial. In 2023, less than half (44%) of 27,131 students agreed that they were involved in the decision making regarding digital services (Jisc Data analytics, 2023). Even if universities do value and use student feedback, this highlights a communication issue with their students, as that leaves 56% of students feeling their voice was unheard.

In 2021, Banki used her own sociology postgraduate students to explore engagement barriers and potential methods to overcome them (Banki, 2021). She stated negative impacts from COVID-19 on home and family life impacted students' attitude to learning, particularly prioritisation. In addition, students being dispersed around the world due to campus closures, only increased the feeling of disconnection. The largest issue identified was students not turning their cameras on, which was combatted with a 'pedagogy of care'. The importance of transparency was stressed to ensure students felt that their concerns were a priority. Students were informed that cameras needed to be on for educators to gauge if the content is engaging enough, as opposed to attendance checking. As a result, more than 95% of her 17 postgraduate students attended the three-hour zoom seminar each week. This was a match to or even greater attendance when compared to previous years, with every student keeping their camera on**.** This suggests students did not want to feel forced to attend lectures when they may have had more vital concerns to be thinking about, like family and health, feeling more inclined to keep their cameras on when they felt their own concerns were being addressed. Although this result may be due to the practitioner delivering the learning, as opposed to the methods themselves, it shows that showing care in the designing and delivery of digital learning can have huge benefits.

Other work since has explored drawbacks of online support and as a result suggested ways to overcome the barriers. There have been recommendations made for training staff and/or students adequately to use technology, particularly focusing on pedagogy and learning processes (García-Morales et al., 2021), with one work finding that having insufficient institutional support, namely the provision of training on

how to use online platforms, significantly increased students' unwillingness to participate online (Akhter et al., 2022). Studies have also recommended clearly communicating with students the expectations and learning goals for online study (Sun et al., 2023, Slack & Priestly, 2023) and unsurprisingly, minimising technical difficulties (Kucharska & Rostek, 2023, Slack & Priestly, 2023). However, there is limited work testing out the recommendations.

2.2.3   Changes to online learning since the pandemic (the blended approach)

At the time of writing (2023), although COVID-19 is still present, the UK has no pandemic related restrictions in place. However, online learning is still being utilised now institutions know that it is possible and have learned of the benefits it brings.

As pandemic restrictions lifted, institutions began to transition out of fully online delivery with many adopting a hybrid or blended learning approach, which offered the benefits of both delivery methods; the social interaction side of in-person with the flexibility of online (The Future of Learning Report 2022). Blended learning has existed in education prior to the pandemic, with varying definitions as technology advanced (Bryan & Volchenkova, 2016). This style of learning can also be synchronous or asynchronous. Potter and Blundell (2022) define a synchronous blended approach as a live learning event that is held in-person and online simultaneously, delivering content to those attending in-person, while using an online video conferencing software for those attending externally. Asynchronous blended learning is the opposite, online and in-person teaching is offered non-simultaneously, for example a mix of in-person and online lectures on separate occasions, or online resources such as recorded lectures alongside in-person lectures or discussion seminars.

Potter and Blundell (2022) reported a case study of running blended tutorials with Open University students on an honours mathematics module. A selection of students were interviewed after the session. Online students talked of attending from home being more convenient for them and the advantages of having the session recorded, and as mentioned earlier, the element of feeling more unseen as an online observer generating more security. Those that attended face-to-face liked the in-person interactions that cannot be replicated online: meeting the tutors and students in-person, observing their body language, and asking questions more dynamically. Everything mentioned here by the students has been discussed as a positive to that approach, or something that was lacking that the other approach could provide and is therefore an example of how offering both can eliminate the negatives of the other.

However, the blended approach presents another hurdle: managing both online and in-person learning at the same time.

> *"Delivering a blended learning program is more work than delivering the entire course in one delivery type"* (Singh, 2003, p.11).

The largest difference is the amount of time offering both modes takes, and how and when both will be provided. Dahmash (2020) used focus groups and interviews to explore blended learning for twelve students on a general intensive English course in Saudi Arabia. The students reported that managing class time and coordination was a problem for instructors. From last minute schedule changes and clashes with other instructors, to spending more time on one mode than the other, giving examples such as in-person classes previously lasting 90 minutes, now extended to three hours when delivered online. However, particularly when delivering synchronously, another element for consideration is how the online mode and in-person mode work together. In Potter and Blundell's 2022 study, an observer mentioned that there was rich discussion between students both online and in-person, but not across the two modes of delivery, and the researchers determined that that was due to the way they had decided to deliver the session. Success in managing both will be finding a balance to what provision is feasible based on the institution, while still providing the additional benefits having both modes brings.

In summary, online learning was present before the pandemic, but the necessity and extent of providing it once restrictions were in place opened up knowledge and opinion of the benefits online learning can bring. However, the same occurred for the disadvantages as well. Research has been conducted in managing these hurdles, and online learning is still being utilised. However, Barber et al. (2021) stated that there are fields that cannot be digitalised, such as physical disciplines like sports and the arts, hence it is important to review the online learning of mathematics specifically, to explore if the same experience is occurring.

2.3 Mathematics education in a digital format

The London Mathematical Society describes mathematics as a long-standing traditional subject often taught in-person with a blackboard or whiteboard so students can observe the correct mathematical notation in application and then repeatedly practice it themselves (The London Mathematical Society, 2010).

> *"...the best way for* [mathematics] *students to acquire skills is by practising as much as possible in conjunction with traditional well-run classroom-based tutorials"* (Foster 2003, p.146)

This method is well established within higher education, with mathematics practitioners quite attached to this approach of teaching.

> *"The professors ... were very tied to the blackboard and mostly represented mathematical objects using formal mathematical language. They thus found themselves suddenly deprived of their "safe place"."* (Cassibba et al. (2021) about the transition due to COVID-19, p5)

However, Pritchard (2015) explains that others feel that lectures are no longer an effective way of teaching. Reinhold et al. (2021) found that even though mathematics students with a higher appreciation for digital learning wanted to see more online teaching, their preference for online mathematics lectures had decreased from before the pandemic to during. Hence, there may be further challenges in the adaptation of teaching mathematics in an online setting compared to those of other disciplines, due to this widely adopted opinion of the best way to teach mathematics.

Discussed below are the common problems with teaching mathematics online, identified across the literature: Mathematical notation, Mathematics anxiety, and collaboration in problem solving. Additionally, online education of mathematics still shares common issues with online learning in general.

2.3.1 Mathematical notation

Probably the largest difference that sets apart mathematics online learning from other subjects is the numerous symbols and strict formatting required that need translating into a digital format. These are easy to handwrite on a board but require additional software or equipment to input online.

> *"It is difficult to achieve sufficient interaction in an online learning environment by displaying mathematical concepts and symbols, which play a significant role in mathematics education, solely through use of a keyboard"* (Karal et al, 2015, p.321)

There have been a number of methods used to combat this. LaTeX is a document preparation software that allows mathematical symbols to be imputed via specific codes and has been used in the mathematics community for many years (Foster, 2003). Microsoft PowerPoint is also a popular teaching tool, which has an equation editor to add mathematical formulae, and an insert function to include handwritten notes which can be scanned in and projected. However, with scanned notes the entire content is presented at once and talked through, as opposed to breaking down each step as it comes. A key part in mathematical understanding is seeing the breakdown of problems, to understand and replicate the steps. This is harder to do when all the information is presented at once and may hinder student's understanding. PowerPoint and Latex's presentation add-on 'Beamer' do allow you to do this but requires you to animate or code each step of the problem to achieve it, which can be very time consuming for larger examples.

This challenge still remained during the pandemic. Cassibba et al. (2021) surveyed 27 Sicilian mathematics professors, who teach mathematics in a range of different disciplines, about the transition to online mathematics during lockdown. Prior to the pandemic, mathematics courses in Sicily were taught with a blackboard and chalk, and this transitioned to online live lectures using MS Teams with educators having no prior experience. 61% of professors used a tablet for writing the mathematical notation and considered it a good replacement (Cassibba et al., 2021). Radmehr and Goodchild (2023) interviewed 10 lecturers and six students from seven higher education institutions in Norway in May

2020. Lecturers used multiple different methods to present their mathematical content, namely recorded lectures with PowerPoint, Latex, or live from the year prior; using an iPad and pen; or setting up a webcam as a document camera and handwriting material.

The tablet and stylus have shown to be a popular synchronous method (see, Pócsová et al. (2021) [p.16], Busto et al. (2021), Jones et al. (2022) as examples), however, as has been established in the previous section, not every student has access to that type of technology, and so would not be able to contribute or practice online. Hence this solution would not benefit all student groups.

Opposingly, there is evidence to suggest that statistics learning is not as affected by the transition to online learning as mathematics is (see, for example, Hodds (2020a)), as it does not share all the same barriers, particularly challenges with mathematical notation. Statistics education often utilises statistical software programs, and so was already utilising technology prior to the pandemic, which can now be taught via screen sharing to multiple devices, as opposed to demonstrating on one. Pan (2003) explored the challenges of teaching statistics in the current (at the time) technology environment, where he reported the advantage:

> "*It* [the online environment] *can be a convenient teaching and learning environment for both students and the teacher*" (Pan, 2003, as cited in Mills & Raju, 2011, p.8)

However, again this relies on having sufficient technology and if students wish to practice, having access to software at home is required, linking to the fact online learning of mathematics and statistics does not escape the barriers online learning in general faces as described in Section 2.2.2.

2.3.2 Anxiety

McNaughton (1996) describes anxiety as '*an adaptive reaction to a potentially dangerous situation*' where clinical anxiety is when this reaction does not fit with the environment or situation, where it can become hard to control. It is associated with feelings of unease, particularly worry, stress or even fear, that can range from mild to severe and can disrupt daily life. Mathematics anxiety, including statistics anxiety, is a condition where this anxiety and stress arise from having to solve mathematics problems or perform any range of numerical manipulation, which then impede one's ability to do so, both during education and in daily life (Richardson & Suinn, 1972).

A 2012 study (Daneshamooz et al., 2012) compared the performance of three groups of 42 Iranian college students, based on their mathematics anxiety and working memory capacity, when learning in either in-person cooperative sessions, with e-learning, or in traditional lectures. They found that students who studied mathematics via e-learning had the highest mathematics anxiety using the mathematics anxiety ratings scale (MARS), and also had worse problem-solving skills than the other two groups of students.

During the pandemic, a German team looked at 123 mathematics students' response to the transition to online learning, particularly how their levels of anxiety, self-expected success, interest, and work ethic impacted that response (Reinhold et al., 2021). Using cluster analysis, they identified two distinct groups of students when controlling for gender and IT preference: 'less promising' and 'more promising'. The 'less promising' group contained those who were highly anxious with low success expectation, work ethic and interest; all said they would like to see more digital aspects of mathematics teaching. However, the 'more promising' students, those who were the opposite, reported a greater social interaction need with peers and lecturers, which as discussed, online learning often lacks, showing again that this new environment may benefit some student groups, but restricts access to others.

Overall, this shows that a sudden change in learning environment, such as the transition to fully online teaching, can influence mathematics anxiety sufferers in a different way entirely, emphasizing that mathematics anxiety is a complicated phobia, that is different for different students.

2.3.3 Interaction and collaboration in problem solving

Pritchard (2015) explains that students must experience applying knowledge obtained in lectures to new problems to truly understand the content. For example, repeated problem solving, step by step proof or disproof of a statement, and testing arguments. Hence mathematics could be seen as a discipline where independent learning, going away and practising in your own time, is a dominant feature, and as online learning has shown to have less learner interaction, mathematics may seem to be less affected by this barrier.

However, there are students that highly value collaboration in problem solving within mathematics. Solomon et al.'s (2010) study of 38 second year maths students reported that they found 51% of respondents preferring to work on problems together as a group and that active learning can be a social experience. In the 2012 Iranian study mentioned above, students who learned cooperatively had a significantly stronger problem-solving ability, regardless of mathematics anxiety and rated themselves with the lowest anxiety compared to students in other learning methods (Daneshamooz et al., 2012).

In addition, although Computer Assisted Assessment technology allows for instant feedback on work, due to reduced learner interaction, lecturers cannot as easily support students as they practice in an online setting, particularly if students do not have the means to write notation, or the confidence to have their cameras on. Sedaghatjou et al. (2023) surveyed 110 STEM (Science, Technology, Engineering, and Mathematics) educators across the globe who were actively teaching during the pandemic in 2020. The participants felt that the most challenging aspect of teaching to convert to online was facilitating group activities, again with some relating it back to students' access to technology.

This in turn can impact student to teacher relationships, which is particularly important for females in mathematics. Solomon et al. (2011) found that for female mathematics students, having a relationship

with their tutors was the main influence on their confidence and access to mathematics in their experience at university. This was still present during the pandemic, as Reinhold et al. (2021) found female mathematics students reported a greater need for social interaction than males in the transition to online learning.

In the CETL-MSOR 2016 conference proceedings, a difference between in-person mathematics teaching and online tutorials was described:

> *"One of the main differences from face-to-face sessions is that the moderator does not have any 'eye contact' with students. It is easy to underestimate how important and useful the opportunity to see student faces (sometimes 'freezing') during tutorials is"* (Namestnikova, 2016, p.76)

This reinforces that lack of interaction, particularly unspoken communication, is a significant drawback to online learning regardless of discipline and was experienced prior to the pandemic. In Cassibba et al. (2021), the mathematics professors were asked in an open question what they felt was lost from teaching during the pandemic. General human exchange (eye contact, seeing the students, actual in-person contact) was once again the largest concern stated by 45% of the 27 professors, followed by interaction specifically for learning purposes, with 26% of mentions. Loss of interaction in any sense was the only downside identified by the professors. Reinhold et al. (2021) also concluded, based on student feedback, that the digitalisation of university learning was not the reason mathematics students wished to return to in-person teaching, but missing the social connections it provided was. Therefore, even without it being the predominant research question of that study, the lack of a social side of university learning when in a digital setting was found again. As this major limitation was also regularly mentioned in the studies of online learning in general discussed earlier, this shows that the loss of the social side of higher education is potentially the largest downside to online learning.

One other factor Reinhold et al. (2021) explored was whether a student looked to find support outside of their traditional degree structure, finding that students who thought more highly of digital methods for teaching mathematics, more regularly sought out outside support. This leads on to the next sections looking at MSS and its transition to online learning.

In summary, there is evidence to show that mathematics has additional factors to consider when teaching in an online setting compared to other disciplines, on top of the barriers online learning faces in general. These additional challenges could result in a more negative opinion towards mathematics online education, and therefore impact the use and opinions of online MSS. However, MSS is traditionally well practised in supporting students with a wide variety of mathematical related problems, particularly anxiety, in all types of support being offered.

2.4 Mathematics and Statistics Support prior to COVID-19

2.4.1 Online support offering before the pandemic

MSS began to develop 30 years ago and has generally been offered as in-person support, with the predominant methods being one-to-one support by bookable appointments, and drop-ins (Lawson et al., 2020). MSS can differ between institutions: from a centralised unit or independent centre to mathematics cafes and office drop-ins (Matthews et al., 2013), with specialised staff offering support up to seven days a week, to postgraduate students offering one or two hours (Mac an Bhaird & Lawson, 2012).

Prior to the pandemic, limited online MSS was offered by institutions both in the UK (Ahmed et al., 2018, Grove et al., 2020,) and globally (Cronin et al., 2016).

MSS centre guides

During the early years, several reports were published acting as guides for practitioners interested in developing MSS at their institution, breaking down everything that they found to be necessary to run an efficient centre, with examples. All were generally written with in-person methods in mind, with limited or no mention of online methods. This absence of significant online support is to be expected with the limitations to technology during the early years of the 21st century, but is important to discuss to establish a starting point for online MSS.

Croft (2000) provides a case study of the support centre at Loughborough University. The author stated that students having in-person access to tutors is "*the single most important attraction*" (p.436), with the centre offering general guidance, as well as more specialised one-to-one tutorials and small group work sessions. The only mention of online support was some computer aided learning (CAL) materials of varying quality, a few '*unpopular*' short videos, and a space for e-copies of the physical resources they offered in the centre, which are all asynchronous support methods.

Three years later, Lawson et al. (2003) published a more general guide in beginning an MSS centre, which included details of a 2001 survey of 95 UK institutions. The authors found that 48% of the institutions offered some form of support. Almost all practitioners stated students having access to in-person one-to-one support was a necessity, sharing the opinion of Croft (2000), and out of 42 responding to a questionnaire regarding what support was offered, 20% revealed that the tutoring staff were the only resource. As for online support, 21 of those (50%) offered some CAL, and online worked examples were also offered by a further quarter.

In the same year, Lawson wrote a small article detailing the use of Coventry University's MSS website, explaining current barriers and how other academics can produce their own (Lawson, 2003b). He stated the website was originally only used for basic information about support offerings, a location for e-resources and a place to email questions. This had now expanded to include more handouts, with the

online tests now having randomly generated questions for multi-use. Short multi-media presentations demonstrating specific activities with commentary were also a new addition. However, all are still asynchronous support methods.

For an international comparison, a guide was published in 2009 detailing support offered by Australian Universities (MacGillivray, 2009), which also involved an investigative survey carried out in 2007. 82% of 39 universities offered mathematics learning support, and once again the most common method was a drop-in service, followed by discipline specific sessions. Slightly more than a third offered workshops and one-to-one appointments, with a few offering sessions to small groups. The only mention of online support was that some institutions supplied web-based resources. This shows that although Australian universities seemed to offer in-person support to the same level, either they offered even less online support than the UK did, or online support was just not considered at that time.

Finally in 2012, Mac an Bhaird and Lawson (2012) authored an updated guide to MSS provisions in universities. By this time, 85% of 103 UK institutions surveyed provided MSS, a 37% increase from the findings of Lawson et al. (2003). Workshops were now explained as an additional method to one-to-one support. Online support was emphasised more in this guide, with the authors describing the importance of a centre having a website, but this was for the use of informing students about the services on offer and a place to store e-copies of material, not for synchronous support. CAL material was stated to now be used by many centres.

Altogether, these guides show there was an increase in the number of institutions offering MSS and having enough knowledge to support other practitioners in establishing new centres. However, there was not significant development of online support services over the 12 years during which these guides were published.

Although not a guide, it is important to mention here that a small-scale trial of an online statistics advice service at three UK universities, Birmingham City University, De Montfort University, and the University of Sunderland, was held in 2011 (Owen et al., 2011). "Elluminate", an online learning space, was set up so students could synchronously meet with a statistics advisor. They would email their short query prior and book a session through google calendar. The trial was led by Owen who had provided online support at Loughborough University for two years prior by the same means.

MSS audit reports
More recently, now MSS centres are more well established across UK higher education and in several other countries, there have been audit reports published; more detailed explorations into how many institutions offer MSS, and the provisions they offer. Levels of online support identified within each source will now be discussed, however it is important to mention that, as with the evidence from the MSS guides, in all the audit reports, in-person face-to-face drop-in, bookable one-to-one appointments and now workshops were still, by far, the most prevalent methods.

In 2012, the extent of MSS provision in the UK was explored, where 85% of the 103 responding institutions offered support, but online provision received no mention (Perkin et al., 2013).

In 2015, MSS provision in Ireland was investigated, where they compared findings to an audit conducted in 2008, and results were published the following year (Cronin et al., 2016). In 2008, 13 Irish institutions submitted a report of their MSS services, nine (69%) of which offered some form of online provision. By 2015, these numbers had grown, with 25 institutions now offering MSS (83% of institutions surveyed) and online provision offered by 12 of them. However, this meant the proportion of Irish institutions offering online MSS had decreased from 69% to 48%.

The types of online support offered had not changed significantly from what was detailed in the guides: useful web links were the most common method of online support, followed closely by a dedicated website and e-resources. An online drop-in service was not offered by anyone; however, 69% who stated they were not offering online support at that time were planning to in the future. Additionally, one institution did offer synchronous support via appointments using an online video conferencing software, a potential beginning to what is seen today.

Ahmed et al. (2018) conducted an audit report of the state of MSS offerings in Scottish Universities. Out of 13, more than 75% offered mathematics and/or statistics support. 62% of universities had some form of online support, which in some institutions included the use of social media. In contrast to workshops now being one of the preferred methods of support, at the time of this audit workshops were the least popular, only offered by 54% of institutions.

The extent of MSS being offered by universities in England and Wales in 2018 was reported in 2020 by Grove et al. (2020). This was now 89% of surveyed universities, with an additional six who did not respond but who had websites indicating evidence of support provision. It was reported that some method of online support was being supplied by 77% of surveyed institutions, including 23% offering synchronous support. However, 66% of those revealed this support was very limited and only offered weekly for one hour or less. Surprisingly however, there was one respondent to the survey whose institution only provided MSS by online means.

Additionally, a report was published specifically looking into the UK and Ireland's MSS online presence during 2018 (Mac an Bhaird et al., 2020a). 100% of 33 responding HE establishments had an online support presence, but again this was mainly a website providing information on provision. However, 30 of the respondents did state they would like to offer more provision online. 19 institutions provided online one-to-one support live using video conferencing software, although five of those reported that uptake of the service was rare.

There is evidence to show that the varieties and extent of online support being offered across the UK and Ireland was gradually increasing before the pandemic. The fact that these methods were beginning

to be explored shows that more practitioners were starting to think about the possibilities offered by new online support methods (and made possible by advances in technology). However, as shown, immediately before the pandemic, online support was still predominantly asynchronous with very limited synchronous support being offered by very few institutions with minimal engagement from students.

2.4.2 Opinions of online support pre-pandemic

Prior to the pandemic there had been a low uptake of online support methods by students. Croft (2000) observed a reluctance from students to fully utilise the CAL materials his centre offered. In Lawson et al. (2003), one in three institutions reported their CAL resources were infrequently used, likewise for the 70% of institutions who supplied students with videos. Those were the only resources that were actively disliked by students.

Mac an Bhaird et al. (2020b), looked at the opinions of students who attended MSS at Maynooth University on their use of their online resources, and 44.7% of 38 students who gave a reason for their non-engagement said they did not even know the resources existed, which was the most predominant answer. Additionally, the same authors (2020a) revealed that 65% of 32 practitioners do not monitor their usage of online resources.

Great consideration is given to the effectiveness of face-to-face methods of support, which institutions began exploring back in 2010 (Matthews et al., 2013), which has not been the case for online support. This may be because, there has not been enough online MSS provision for any meaningful evaluation. Or potentially, as with the studies of online learning in general, there are still both practitioners and students that feel face-to-face teaching of any variety is the better option, as several studies of MSS have also found.

There are multiple instances of finding a preference for face-to-face MSS over online throughout literature prior to the pandemic. For students, O'Sullivan et al. (2014) surveyed 1,633 first year Irish service mathematics students about MSS in 2011. Of the 112 additional comments about online support measures, 12.5% were about needing or preferring help in-person. Additionally, Mac an Bhaird et al. (2020b) found that when 38 Maynooth University students stated why they do not access online support, the majority said they were unaware it was available, but 28.9% stated they preferred physical support. It was also found that practitioners recognised this opinion in students, as just over half the practitioners surveyed (54% of 30) in Cronin et al. (2016) revealed they believed students prefer face-to-face support. But practitioners themselves also had this preference. Mac an Bhaird et al. (2020a) found 70% of the 23 practitioners who gave negative comments towards online support stated that online should not replace face-to-face. When practitioners were asked about the limitations of online support, 19% of 31 just stated a preference for face-to-face.

One-to-one help has repeatedly been identified as the most valued element of MSS by students and practitioners alike (Lawson et al., 2003; Mac an Bhaird & Lawson, 2012; Cronin et al., 2016).

> *"Feedback from students shows that they appreciate this* [personal] *service most of all, and we have little doubt that if it were not available students would be less likely to use the Centre."* (Croft, 2000, p.437)

However, one-to-one support can still occur online with synchronous methods. Evidence has shown that most institutions were not offering high levels of this before the pandemic, and as shown (for example, Mac an Bhaird et al., 2020a, and Grove et al., 2020), there was still not a significant positive response or uptake of online support methods from institutions who did offer this support prior to the pandemic.

However, not all opinion was negative. The 2011 pilot for a shared online statistics advisory service mentioned earlier, found that both students and staff thought the use of sharing statistical software simultaneously via an online meeting tool was very easy and beneficial (Owen et al., 2011). Additionally, when asked about the perceived benefits online support can offer in Mac an Bhaird et al. (2020a), 32.3% of 31 practitioners said it could benefit distance learners, the advantage regularly identified with online learning in general.

2.4.3 Barriers to the provision of online MSS (before the pandemic)

MSS practitioners' perceived barriers to online support prior to the pandemic were similar to those for online learning in general and for mathematics online learning in particular (as discussed above in Sections 2.2 and 2.3).

In Cronin et al. (2016), practitioners claimed face-to-face was more effective:

> "*This* [face-to-face support] *was said to be more effective since it obviously enables students to talk through their problems*" (Cronin et al., 2016, p24)

The above reasoning is very similar to the reduced interaction barrier. Further, one participant in that study expressed the view that weaker ability students in particular need in-person support to help increase confidence. This is reflective of mathematics anxiety, as confidence in one's ability can be a route to the condition.

> "*These students* [anxious, bored, fearful, or think maths is unimportant] *often have a very low confidence in their mathematical abilities… the main emphasis of any teaching has to be diverted from teaching the mathematics content to giving the students confidence*" (Metje et al., 2007, p.81)

In Mac an Bhaird et al., (2020a), technological issues were mentioned by 29% of 31 participants. Additionally, staffing constraints involving inadequate training and lack of time were now revealed to be an obstacle, mentioned by 86.7%, the largest theme of barriers to ICT identified.

Overall, before the pandemic, it took just short of two decades for the majority of institutions to begin offering synchronous online support, which was usually a very minor offering compared to other services offered. This was partly due to initial technological limitations but was probably more driven by practitioners believing online support could not be offered to the same level of quality as face-to-face support, in part due to those technological limitations. Opinions and uptake of online support by students were also generally low. This emphasises just how large the impact on MSS centres around the world was when the pandemic began.

2.5 MSS since the pandemic

Like all education in the UK and around the world, MSS was forced online during the COVID-19 pandemic, and due to most institutions offering limited amounts of online support prior, the transition was sudden, and most were unprepared for it.

2.5.1 Support provision

Hodds (2020a) reports on a survey exploring the initial efforts from 72 individual institutions (53 UK, 11 Irish and eight from the rest of the world, namely mainland Europe, the US and Australia), in response to the sudden transition. It ran alongside the **sigma** Network's (a collaborative cross-university network for MSS practitioners) first ever online workshop two months into the UK's lockdown.

As with the findings from the surveys conducted before the pandemic, very few UK institutions were offering online support prior, with 40% offering some form, only two of which were synchronous. This rapidly increased to 94% during the pandemic, including 27 institutions that had not previously been considering any online support. The focus of this newly available online support for practitioners in the UK was one-to-one appointments and workshops using video conferencing and online collaboration software. 95% of institutions outside the UK were also offering at least one form of online support, but in contrast were more focused on online drop-in.

A similar result was found for MSS in the USA (Johns & Mills, 2021). Out of 28 survey respondents, 11% offered online support before the pandemic began. This drastically changed to every institution offering online drop-in support during the pandemic; 43% additionally offering booked online appointments and another quarter supplied asynchronous online material.

This shows that it is possible for institutions to offer online MSS, but it required a significant push to overcome whatever barriers were preventing them from doing so before, as many would not have introduced online support otherwise. Whether that was time, resources, lack of ideas, or a preference

for face-to-face, practitioners were forced to come up with online support methods in order to keep providing MSS, regardless of the difficulties.

Reports of MSS provision during the height of the pandemic reflected on the transition to online learning, exploring what methods were used and associated practitioner opinions. Many often ended with a prediction or intent for the future for online MSS, in that face-to-face support would return but some aspects of online support would remain (see Hodds, 2020a; Mac an Bhaird et al., 2021; Mullen et al., 2021 as a few examples). These predictions held true, and, as institutions re-opened after pandemic-enforced closures, many institutions began offering a blended form of MSS (for example, Mullen et al., 2023). However, there is currently a gap in reports, in terms of large-scale surveys, of what MSS institutions are presently offering, which would be needed in order to explore whether this blended approach was maintained.

At the time of writing, Coventry University's MSS centre, **sigma**, the institution at which this PhD study is based, currently offer a blended approach to delivering MSS. They offer both an online and in-person drop-in service as well as 50-minute pre-bookable appointments that can be either online or in-person at the students' preference. In addition to that, 20-minute online sessions can be arranged as an alternative if a student has a shorter query and cannot make the time online drop-in support is offered at. Online workshops for mathematics and statistics are also offered with recordings and presentation slides of previous sessions accessible on their website. The website provides information about **sigma** and the services on offer, a place to book appointments and access online drop-in, FAQs, contact information for the staff, and resources. Worksheet resources can be accessed on the website as PDFs or printed off in the physical centre for free (see https://sigma.coventry.ac.uk/).

2.5.2 Student opinion and engagement

An overarching similarity was identified across reports of MSS provision during the pandemic: student uptake had significantly decreased. 74% of UK and 82% of Irish institutions surveyed in Hodds (2020a) saw lower engagement numbers from students. As an example, Coventry University's **sigma** centre saw more than 1000 students accessing support during April 2019, which dropped to below 200 in April 2020 (Hodds, 2020b).

The same occurrence was observed in MSS outside of the UK. Hodds (2020a) found that 63% of establishments from the rest of the world found a decrease, with the number of students who used an online MSS service between March-May 2020 averaging between 101 and 500 students. It was emphasised that some institutions would have seen those numbers in a single day prior to the pandemic. During Autumn 2019, Western Sydney University received an average 48 student consultations per week and only 22 in the same period in 2020, a drop of 54% (Shearman et al., 2020). For University College Dublin, drop-in numbers dropped by 59% between April and December 2020 compared to the

same period the year before (Mullen at al., 2022). In the USA survey, 89% of universities also stated a significant decrease in student numbers since the pandemic (Johns & Mills, 2021).

However, in 2021, Mullen et al. explored student and tutor perspectives of online support during COVID-19 at one institution in Ireland and one in Australia. They state that even though online support was being utilised much less than in-person support was prior to the pandemic, online bookings had begun to increase at the beginning of the 2020/21 academic year. Mac an Bhaird et al. (2021) also saw an increase in average engagement figures in semester one of the same year.

There has been limited work published on student opinion of online MSS since the beginning of the pandemic, as the focus was mainly on those responsible for making the transition. Mullen et al. (2021) found mixed opinions, where one student explained it was just easier to use YouTube as it was available 24/7, whereas others approved of the new accessibility preventing them using the excuse of having to travel to campus. Interestingly, two students claimed they used online MSS more because they were struggling with the online aspect of learning mathematics and so decided to access MSS. Mac an Bhaird et al. (2021) explored student opinion of new online workspaces that had been implemented by the MSSC (Mathematics and Statistics Support centre) at Maynooth University to try and encourage more engagement. Response from engagers was mainly positive, particularly about staff and the recovered social aspect that online learning lacks. A small number of negative comments were about timetabling issues, the impact from lack of engagement from other students, and advertising. Mullen et al. (2022) revealed that students were unaware how social mathematical learning is, where they found that in-person, they used to 'accidentally' learn off their peers and did not realise until the pandemic took it away.

Mullen et al. (2023) explored the provision of online, in-person, and blended MSS at University College Dublin compared to Western Sydney Australia. They surveyed 227 users of MSS in total across six surveys, one given to each of the three explored groups of students, online-only users, in-person only users, and users who had used both modes of support, at both locations. Overall, students, regardless of their usage, were highly satisfied with both in-person and online support. However, in part of the survey, students were given seven scenarios, such as being on campus and having a quick question, being at home and having a complex question, or having an assessment due soon, where they had to choose which mode of support they would access to address each scenario: in-person or online. With the exception of the two scenarios that stated the student was at home, in-person support was the preferred choice. They reasoned that this may be due to students following what they were familiar with. Additionally, they found that all students, even those who had only used online support, stated they would likely be more persistent with trying to solve a problem if they were using in-person support as opposed to online support. This raised an interesting question of whether students' preference aligns with what is best for their learning. However, students who had used both types of support did rate the

quality of the in-person learning environment significantly lower than those who had only used in-person support. The authors concluded this may have been a result of those students experiencing the higher noise level of in-person setting compared to that of online, resulting in the less positive rating. The authors did conclude however that there was a preference for a mix of modes in the future.

As there is now some evidence of increasing engagement with MSS since the drastic reduction at the start of the pandemic, it suggests that there was something other than dislike of online support initially preventing students from engaging with online support. Students had to use considerable energy in adjusting to the solely online provision of their standard university teaching in the first stage of the pandemic, which may have left limited energy to consider engaging with voluntary learning activities such as MSS. Together with other outside factors relating to the pandemic, for example health, isolation, and family concerns, there is probable cause to believe this was an influential factor in students' non-engagement and opinion. However, further, more recent investigation into student engagement and opinion, with restrictions having been lifted and the impact on daily life not being as extreme for many, could help to identify how much of the engagement problem lay solely within online MSS methods. With the pandemic falling further into the past, it would be helpful to determine if and why online MSS methods are less favourable than in-person methods.

2.5.3   Opinions from practitioners

The same negative opinions towards online learning identified in earlier sections of this review were present in practitioners' opinions of online MSS during the pandemic. In Hodds (2020a), just over half of UK practitioners said that they thought online was worse than in-person support and a very large proportion of practitioners from the rest of the world gave statements that face-to-face was better. This shows that, even when forced to explore more methods of online support, a lack of eagerness was still present.

The main reason given for this conclusion was the lack of non-verbal communication, particularly due to lack of cameras being switched on. Mullen et al., (2022) found that MSS tutors felt that online support had a disconnectedness. Technological issues were also a concern, ranging from connectivity trouble due to poor internet access, to faults in equipment such as microphones. Both were prominent concerns identified throughout this review, emphasising that these were the current main barriers to online MSS and online learning in general during the pandemic. Although not mentioned as much, practitioners were also concerned in some cases that students do not have the necessary equipment such as writing tablets, the preferred method for mathematics notation online (Hodds, 2020a; Shearman et al., 2020; Johns & Mills, 2021).

Practitioners also felt that they were not trained enough to deliver successful online support and struggled to find the time to learn amidst the pandemic (Hodds, 2020a). This is reflective of findings for online learning in general, shown in the staff polling in *Gravity Assist*. Staff were asked if they felt

they possessed the skills and knowledge necessary to create and provide digital teaching, to which 536 gave a response. Most only felt fairly confident (59%), with 20% feeling fairly to very unconfident or unsure. Additionally, only 67% felt supported by their institution to do this (Barber et al., 2021). Similarly, a report detailing the experience of six MSS tutors from Maynooth University during the transition revealed they only received "some guidance" in the methods they utilised, but it was mainly their own responsibility (Heraty et al., 2021). This was a concern brought up in online MSS prior to the pandemic, amplified by the sudden transition and lack of preparedness.

On the other hand, the most mentioned benefit to online learning was once again flexibility, particularly reaching external campuses, having less constraints on time, and the availability to a larger range of students (Hodds, 2020a; Shearman et al., 2020; Hodds, 2020b; Johns & Mills, 2021). Additionally, 72% of the UK and over 80% of Irish practitioners stated they would continue with some form of online support once the pandemic was over. The rest of the world was a little more reluctant, but 33% still agreed (Hodds, 2020a). In Johns and Mills (2021), only 13% stated they would not continue, with 54% maybe continuing and 33% definitely continuing. This implies that practitioners must have seen enough benefit to want to continue with online support and not return to entirely face-to-face.

Overall, the percentage of MSS centres around the world offering synchronous online support drastically increased during the pandemic, however the same hurdles identified for online learning in the past were still present. These hurdles, along with the sudden transition, caused the initial negative response towards online MSS, particularly in the uptake from students, and as a result caused more negative opinion from all concerned.

It is important to mention that a key conclusion from the *Gravity Assist* report was that for high quality teaching, technology cannot just be added on to a recreation of original teaching methods in this new setting (Barber et al., 2021). This statement is in complete contrast to how MSS practitioners around the world transitioned to online MSS during the pandemic. Technology issues aside, the negative opinions and drawbacks identified by practitioners could have potentially just been a result of a method not being an exact re-creation of when it was in-person and heavily influenced by all the negative connotations of the global pandemic. Also, people tend to prefer what they know and instinctively think that things that they have not tried will not be as, or even any, good. But when they do it may change their opinion and find that it is better than they thought it would be (as seen in Cassibba et al. (2021)). Together with the fact that there has been limited research on student opinion since the pandemic began, it is therefore important to now compare this initial provision and reception to current offering and opinion, which will be explored later in this study.

2.6 Conclusion

This chapter began by reviewing online learning in higher education, in particular the benefits and barriers perceived by both students and educators prior to, during and since the global COVID-19 pandemic.

As online learning began to feature more within education, educators became more open to the advantages it provided and the offer of new opportunities. Flexibility is regarded as a huge, if not the largest benefit of online learning, regularly identified prior to, during and post-pandemic, regardless of discipline. Not constrained to a physical location, students can access content from their homes at a time that fits with their personalised schedule. Now mostly in a blended learning approach, this greater access that online learning provides has prevented many MSS practitioners returning to a fully face-to-face support service. However, there are still drawbacks, often affecting some student groups more the others, particularly the loss of both academic and social interaction. This limitation was even being identified in studies where interaction was not a specific focus, emphasizing its importance to students and staff alike.

Narrowing down the focus, teaching of mathematics online specifically was discussed, presenting both the shared and unique challenges the discipline faces compared to other subject areas. Loss of interaction was also evident in mathematics online education, notably in the loss of collaboration in problem solving. Mathematical notation in an online setting also produces a particular challenge, which has produced an array of methods in addressing it, all with their own benefits and drawbacks. There has been some exploration into overcoming these barriers, the use of tablets and styluses, emphasizing pedagogy of care, and technological training with a focus on learning processes, but these have mainly been suggestions, allowing for future work to build on.

This informative foundation then led into reviewing the background of the area of exploration in which this PhD study is based. MSS provision, and opinions of staff and students, prior to and during the early stages of the pandemic were explored so that future comparisons can be made.

MSS practitioners' opinions had begun to change since the pandemic. From very limited online support being offered or planned for the future by UK and international institutions alike prior to the pandemic, to practitioners finding the same benefits as online learning in general and wanting to continue with some form in the future. Even with the lower uptake of online MSS, it is recognised that removing it completely would alienate some student groups. This is important to consider as it has regularly been reported that there are students still not engaging with MSS, even before the pandemic caused a further significant decrease.

Research at the height of the pandemic focused mainly on what institutions were providing in the panic driven transition to online delivery, with the associated opinions of the people responsible for those

changes and predictions for the future. As a result, student opinion of online MSS has seldom been reported since the COVID-19 outbreak, as well as exploration into how provision and practitioner opinion may have changed, or lived up to early predictions made, since this initial period.

Right from the beginning, the integration of online methods into HE occurred at a slow rate, possibly due to limited knowledge and experience, with some adamant that face-to-face is the superior mode of teaching. When the HE institutions throughout the world were forced to solely use only online learning, they were generally unprepared for it, and this may have further reinforced negative opinions of online learning. Therefore, even though there is still a preference for in-person teaching, it is important to reflect on and retain what has been learned in all areas of education, addressing discovered barriers rather than retreating to traditional ways, particularly as COVID-19 is still present three years past the initial outbreak. If something like this were to happen again, we may just repeat past mistakes.

Therefore, this thesis intends to give insight into identified gaps in the literature, exploring MSS provision and related opinion of users and providers after the initial panic-driven transition period to online provision. The scope will cover multiple institutions in and outside the UK to offer more generalisable findings, which is particularly important for the main aim of providing informed recommendations of future practice of MSS, that consider measures to overcome identified barriers and increase student engagement with MSS in our new normal.

3 Methodology

This chapter provides a foundation and overview of the general methodology used during this three phase PhD study. Specific details on how the methods discussed here were used during each phase can be found in subsequent Chapters: 4, 5 and 6.

It begins with a discussion of the study's research problem, giving an overview of the study as a whole, before presenting the specific research questions that were addressed. Section 3.2 then discusses appropriate research approaches, followed by the data collection methods appropriate for the chosen approach in Section 3.3. Methodology choices are described and justified in the context of this research. Ethical considerations that were made are detailed in Section 3.4. Section 3.5 provides an overview of any quantitative and qualitative data analysis that was performed during the study, before any limitations of this research are identified and rationalised in Section 3.5. A final summary of the chapter is provided in Section 3.6.

3.1 The Research Problem

3.1.1 Study overview

Prior to the global COVID-19 pandemic, institutions around the world offered little to no online mathematics and statistics support (MSS), and those that did often only supplied a website for advertising purposes and access to resources (Hodds 2020a; Mac an Bhaird et al., 2020a). As a consequence, the majority of institutions were poorly prepared to shift all support to online provision when the pandemic began. It has also been regularly reported that there are students who are not accessing support provisions at their university who may benefit from utilising it (Symonds et al., 2008; Patel & Rossiter, 2009; O'Sullivan et al., 2014), even before the pandemic had a significant negative impact on student engagement (Hodds, 2020a). Three years post outbreak and living in the 'new normal', MSS provision has shifted from solely online to some level of blended provision of both in-person and online services. This study aims to explore what MSS provision in a post-pandemic world should look like.

This study was broken into three key stages, namely investigations into the practitioner perspective, the student perspective with a focus on barriers to engagement, and finally the pedagogy of online versus in-person MSS. Opinions from both providers and users of MSS at universities across the world, together with observations of pedagogy, will be used to make informed recommendations for good practice in the provision of MSS in 'the new normal', in the form of a framework. The framework will be designed based on the key findings from each stage of this study, including preferred methods of support and to what extent they should be offered, with a particular focus on student engagement. It will be influenced by both UK and international institutions with the intent of the recommendations being beneficial to any institution providing MSS.

The remainder of this section details the research questions being explored, before discussing appropriate research approaches and methods best suited to achieve the overall aim of this study, and any ethical considerations taken throughout. Finally, general methodological limitations are addressed before giving a closing summary.

3.1.2 Research Questions

As described in the previous section, the overall aim of this PhD study was to make a framework of informed recommendations for good practice in the provision of MSS in the 'new normal', based on exploration and reflection of MSS practice prior to, during and coming out of the pandemic. This aim is represented by the final research question listed below.

The first five questions have been considered in order to help answer this final overarching question. MSS was initially created to help those students who would otherwise drop out of their university degree course due to being inadequately prepared for handling the mathematical content involved, so for some, MSS is a lifeline. Because of that, students are the main stakeholders of MSS as they gain the most benefit and would therefore suffer the most without its continuously growing provision. However, there is another group of people who are also essential to the existence of MSS, the practitioners who design and deliver the provision, and who are responsible for adapting support alongside the changes of education over time. Hence gaining an understanding of the opinion of both of these groups was vital for making recommendations of good practice.

However, neither of these groups' opinions should be considered alone as both can be subject to their own biases. For example, some students just want tutors to do their work for them or get disappointed when they cannot receive help on work that will be assessed, and so their opinion of MSS can reflect that. For practitioners, some may state in-person support as superior (and therefore can see students as feeling the same) only because they have not experienced online support for as long or discovered the best methods and technologies to overcome any hurdles they have faced. Therefore, gaining an outside neutral view is needed, to compare opinions to what can be physically seen happening, by someone not directly involved.

Hence, RQ1 and RQ2 are focused on the practitioner perspective, the student perspective is explored with RQ3 and RQ4, RQ5 investigates pedagogy from an outside view, and RQ6 is what this study aims to discover overall:

>   **RQ1:** What mathematics and/or statistics support methods did institutions in the UK and the rest of the world offer ***prior to*** and ***during*** the pandemic?

>   **RQ2:** What were the ***practitioner*** opinions of online MSS provision at the start of the pandemic and how did these change as the pandemic progressed?

RQ3: What is the *student* opinion of MSS provision and its effectiveness since the pandemic?

RQ4: What are the current barriers to student engagement with MSS and what can institutions do to reduce these barriers?

RQ5: Is there a significant difference in pedagogy based on whether MSS is delivered online or in-person, and what influence, if any, does this have on students?

RQ6: What constitutes good practice in MSS provision in the 'new normal'?

The following two sections explore key approaches to research as well as a selection of research methods. They also justify why each has been chosen to help answer the above research questions, the answers to which were used to formulate a framework for good practice in MSS provision, answering the overarching research question, RQ6.

3.2 Research approaches

Research philosophy is the approach taken towards investigating a phenomenon; a clarification of the overall research strategy that will be used (Crossan, 2003). Consideration of research philosophy prior to carrying out a study can help pre-determine what research procedures are going to be used. This is done by evaluating the limitations of various methods, what kind of data needs to be collected and how it is going to be analysed and interpreted, and finally, how that can answer the research questions that have been proposed (Easterby-Smith et al., 1997 as cited in Crosson, 2003). This section will describe and justify research approaches and methods that were used in the context of this research study.

3.2.1 Quantitative and Qualitative research

Lincoln and Guba (1985) define a paradigm as a set of beliefs and their associated methods. Positivism, dealing with observable reality and looking at making generalisations, and interpretivism, dealing with non-physical phenomena and exploring deeper meanings, are two commonly adopted paradigms in research (Alharahsheh & Pius, 2020). Quantitative and qualitative research lie within these two paradigms.

Quantitative research uses numerical data, often to explore a phenomenon or occurrence in the physical world with the aim to prove or disprove accompanying assumptions about its causes. Qualitative research uses non numerical data (e.g., textual, audio, and visual) and is used to explore social phenomena: human beliefs, motivations, and opinions. It aims to understand experiences from other perspectives rather than just observations from your own (Firestone, 1987). However, social concepts can also be represented using numerical data, for example by using a Likert scale to numerically rate someone's level of agreement with a concept.

Due to the paradigm from which it stems, quantitative research is primarily objective. Environments are controlled to reduce the influence of confounding variables, and the researcher remains detached from experimentation to minimise personal bias. Procedures are standardised to be easily replicable and collect large amounts of data in a short period of time, resulting in high reliability and generalisability of findings. However, as the resultant data is numerical, hurdles arise when the phenomenon being observed is not easily quantifiable.

Qualitative research can be used to analyse more complex constructs that are not as easily expressed as a quantity. The subjects of this type of research are generally humans, where multiple perspectives are questioned and observed. As a result, qualitative research can produce vast quantities of highly detailed, in-depth data. Consequently, analysing this amount of this type of data is very time consuming. Sampling and opportunity are often more constrained due to scheduling difficulties, and also findings are less generalisable due to the diversity in human characteristics.

However, when both research types are used in collaboration, the weaknesses of one can be counterbalanced by the strengths of the other.

3.2.2 Mixed methods

Qualitative and quantitative research used to be thought of as very different and incompatible paradigms (Clark, 1998), but since the late 1980s, there has been a growing interest in using these methods in combination (Maxwell, 2016). Researchers realised the benefits of combining both approaches and mixed methods research designs became more accepted and widely used.

Tashakkori and Creswell (2007) define mixed methods as the gathering and analysis of data, integrating findings, and generating conclusions using both quantitative and qualitative methods or approaches in a single study or investigation. They state that a mixed methods design is thought of as either the collection and analysis of both qualitative and quantitative data (method focused), or the integration of qualitative and quantitative approaches (methodology focused). This study uses the first.

Mixed methods can be broken up into different typologies that describe the order of integrating the two approaches and the different purposes that that achieves. Creswell and Clark have fluctuated with how many main types there are but have currently identified three core designs (Creswell & Clark, 2017). The designs are as follows:

Explanatory sequential:	In this design, quantitative methods are used first, followed by qualitative, and the integration of the two happens when the data is analysed and interpreted. The qualitative phase is used subsequently to explain and enhance the quantitative results (Creswell et al., 2003). This design is straightforward and can be used to explain any unanswered questions that were produced in the first phase of results.
Exploratory sequential:	This sequential design is the reverse of the explanatory design, where qualitative methods are used first in order to help determine what quantitative methods should follow (Doyle et al., 2009). Quantitative data can also be used to help generalise a theory produced from the qualitative analysis (Morse, 1991 as cited in Creswell et al., 2003).
Convergent:	Previously known as triangulation, this design is when both quantitative and qualitative phases happen at the same time, trying to answer the same questions, but separately, collecting the same amount of data where neither is the more dominant method. The phases help to complement each other by counteracting the other's weaknesses, often used to confirm, assess the generalisability of, or give extra evidence in support of findings from the other (Creswell et al., 2003).

The following three designs were previously discussed as main typologies (Creswell & Plano Clark, 2011); however, it was decided that they are more general terms than unique designs, used in the foundational philosophy or application of the core designs above (Creswell & Plano Clark, 2017). However, these are also important to discuss as Creswell et al. (2011) stress that the designs are not strict and finite but illustrate a variety of possible approaches to mixed methods that researchers have used (Creswell et al., 2011). These designs are:

Embedded:	Both quantitative and qualitative phases happen at the same time in this design, but one phase is located within the other, with the latter being the more dominant method. This is often used to gain more depth and perspective from the data (Caracelli & Greene, 1997). For example, observing the behaviour of participants while they are completing a test (Zydney, 2008). The main source of data is quantitative and comes from the performance of individuals before and after an intervention, but qualitative data is collected during the testing via observations.

Transformative:	A transformative approach places a 'transformational-value' or 'action-orientated' advocacy-based lens on to research, with the main goal being advocating a change (Creswell et al., 2003). There is an emphasis on societal issues, where the research is used to advocate for the participants involved, often those with alternative or diverse perspectives, giving them a voice for their concerns. More emphasis is placed on the issues being addressed rather than the methodology used, so qualitative and quantitative data can be collected in any order, or at the same time, based on the needs of the researchers (Hanson et al., 2005). Flexibility is possible in this design, where the researcher can adapt if unexpected findings and new understandings arise (Barnes, 2019).
Multiphase:	The multiphase design involves multiple studies conducted over time that are connected by a common goal. Convergent and sequential aspects are used within the multiphase design, where the individual projects can be either solely quantitative or qualitative, or both, and build upon each other to achieve the overall aim (Creswell et al., 2011).

There are both positives and negatives to using a mixed methods design in research. Different methods are sometimes needed to address different research questions within a study or different parts of the overall research aim, particularly when complex phenomena are being explored. Qualitative and quantitative approaches also have their own weaknesses, as discussed in the previous section, which can be reduced when used in combination (O'Cathain et al., 2007). Mixed methods can also be used to understand links or contradictions between qualitative and quantitative data, creating a more enriched experience by giving a deeper understanding of the phenomenon being explored. However, using multiple methods increases complexity, requiring different knowledge and expertise, and therefore can be more time and resource consuming (Shorten & Smith, 2017).

Using a mixed methods design for this research into mathematics and statistics support is necessary. MSS is not a compulsory service; students make a choice of whether they want to access services or not. Hence in the context of this study, when exploring aspects such as changes in provision, or engagement, quantitative data can describe the current picture, but the reasons behind why that picture looks the way it does, are rooted in opinion and individual experience. For example, collecting solely quantitative data, such as engagement numbers or demographic characteristics, can reveal who is using the services and what support they are accessing, but not explain why certain students are or are not utilising services. On the other hand, collecting solely qualitative data can give an understanding of current views, but runs the risk of participants not providing their true opinion and also of the views of participants not being representative of the wider population. Without quantitative data to provide a

basis for comparison, deeper meaning behind that view is lost. Hence the research questions being addressed in the study cannot be answered with only one approach.

As this study aimed to gather data from practitioners and students around the world, the main source of data collection needed to be simple, fast, and easily distributable. However, opinion-based data was needed, and so only using quantitative methods would have resulted in a lack of detail. Therefore, an explanatory design was chosen. This allowed for the first stage of data collection to be quantitative, where substantial amounts of data could be collected quickly, and then qualitative methods could be used to gather richer, more detailed data to further explain any phenomena identified and give the findings more meaning.

3.3   Data collection methods

Based on the chosen research design and the type of data to be collected, the following section details and evaluates relevant data collection methods that are commonly used and explains why they have been chosen for this study.

3.3.1   Questionnaires

Questionnaires are a series of questions, delivered online or in-person, used to collect data from a targeted population in a written format (Marshall, 2005). They can contain one to several different types of questions, that can produce both quantitative and qualitative data. Closed questions, where there are only a limited choice of answers (such as single or multiple-choice questions and scale questions), produce quantitative data and require statistical methods to analyse. Open-ended questions requiring a free text response generate qualitative data, which can be analysed qualitatively. Responses could also be given a numerical representation, based on the key ideas within each, and analysed with quantitative methods if desired. The questions used on a specific questionnaire will depend on the aim of the research and the type of data being collected. Both open and closed questions can be used in the same questionnaire.

When designing the questions in a survey, particularly if delivered via paper, it is crucial to not only have grammatically correct questions that are spelt correctly, but also that the questions are achieving the desired response. Once the survey is delivered, there is usually no chance to edit them without influencing answers. This is why pilot testing is invaluable. Pilot testing is where the questionnaire is given to a small sample of individuals who complete the survey to test the functionality and the outcome of the questions, so they can be refined, if necessary, before being released to the larger target population. Any errors in the questions, or potential pitfalls in receiving the desired response from misinterpretation, can be identified and modified.

Wording of questions should be chosen strategically to be applicable to the population being targeted, controlling for participant bias. This should ensure that data representative of the phenomena being explored is produced. Participant bias is where a participant's answer to a question is influenced by some factor other than the content of the question (Paulhus, 1991). One example is leading questions, where emotive language is used to influence the participant to choose a specific answer (Marshall, 2005), which may deter participants giving their honest opinion and influence the outcome of research. Another bias would be the selection of answers without thought, particularly with Likert scale questions. These involve a statement to which the respondent has to select a value on the scale to represent their attitude, opinion, evaluation, or intention towards the subject of the statement. A combination of positively and negatively worded questions can be used to increase focus on the questions asked (Zeng et al., 2020), where the negatively worded questions act as 'speed bumps', forcing the respondent to answer with attention rather than just act automatically (Podsakoff et al., 2003).

The questionnaire can be an asynchronous research method, delivered on paper or online, meaning the researcher does not have to be present at the time of data collection. Therefore, questionnaires can be run for long periods of time and target a widely spread sample of people. This also means a questionnaire can be fully anonymised, thereby increasing the probability participants will be honest in their answers as they cannot be identified.

However, asynchronous research also has disadvantages. If participants need clarification on a question, they are unable to receive it immediately, which may result in them leaving the question blank or interpreting it differently from what was intended by the researcher. Marshall (2005) also points out that due to anonymity, there is no way of knowing if the questionnaire has been completed by a member of the target population, as dishonesty is easily achievable. Alternatively, particularly with the paper mode of delivery, the researcher can be present at the time of collection to assist participants in the correct interpretation of the questions where required, but this may be more time consuming and not practical or even possible when collecting data from participants around the world.

Another issue questionnaires face as a research method is survey fatigue; the idea that exposing a population to multiple surveys regularly can result in a supressed or nonresponse rate, particularly when the surveys are delivered back-to-back (Porter et al., 2004). In the UK, many students are asked to complete several questionnaires throughout the academic year, from localised questionnaires for giving feedback on university activities, to large scale national surveys such as the National Student Survey. This was also exaggerated by the COVID-19 pandemic, where in-person data collection was not an option. A way to overcome this can be strategically timing the release of the questionnaire so as to not overlap with other known surveys; finding a balance between leaving sufficient time in between and conducting it at the best time for the research aim. Additionally, Porter et al. (2004) theorise that surveys

of interest to the target population may not generate as much survey fatigue, and so finding ways to make the questionnaire or its aims interesting to potential participants can be another mitigation.

As stated in the previous section, this study aimed to collect data from practitioners and students across the world, therefore the main source of data collection needed to be easily distributable. Since questionnaires can collect both quantitative and qualitative data simultaneously to gather a wide range of data, which is important when exploring new experiences, this method was chosen for this study. The design and use of the questionnaires in this study will be discussed in more detail in Chapter 4 and Chapter 5.

3.3.2 Interviews

The interview is one of the most widely used techniques in qualitative research. There are three types of research interview which vary with the type of data being collected:

Structured: In structured interviews, a set of pre-determined questions, in a specified order, is strictly followed. All participants receive the same questions in the same sequence with little to no deviation in order to remain consistent. The questions are designed to have a limited range of response options which are recorded using a coding scheme. This allows little variation in responses, except where open questions are used, however this is infrequent (Denzin, 2008). Due to these characteristics, a larger number of participants can be interviewed in a shorter space of time compared to the other interview types, as the interviews take less time to complete. However, the data can lack detail as the participants have less freedom in their answers due to the closed nature of the questions.

Unstructured: The unstructured interview is compared more to a "*free-flowing*" conversation as opposed to an interview (Blackman, 2002). Few prompts are prepared prior, and the structure and content of the interview are entirely directed by the information the participant shares and the follow up questions the interviewer asks. Unstructured interviews allow participants complete freedom in responses, producing a vast amount of rich qualitative data, significantly varying in length. This interview type tends to be much longer than the other types due to the participants having no constraints in what information is shared and they can therefore be very time consuming to conduct. As a result, generating the transcript and analysing the data will also be increasingly time consuming and identifying themes across participants' responses can be a challenge as they may discuss a variety of different things.

| | Semi-structured interviews are somewhat in between the other two interview types and are most commonly used. The general plan for the interview, as well as broad prompts or questions, are designed beforehand, however, the flow of the interview is determined by the participants' answers (Stuckey, 2013). The questions can be a mix of closed and open-ended questions, and the researcher has the freedom to follow up on anything that was said. As a result, the volume of material gathered tends to be greater than in a structured interview but less than in an unstructured one. Thematic analysis is often used to analyse the qualitative data collected from semi-structured interviews (Braun & Clark, 2006). |
| **Semi-structured:** | |

Unlike the questionnaire, interviews collect data from the participants synchronously and can collect more detailed in-depth data as participants are not restricted to the written word and space in a response box. Having the researcher present allows for any questions the participants may have to be answered and any clarification of questions instantly provided. The researcher also has the option to follow up on anything shared for additional information. Additional context can also be provided through the use of social cues, such as body language and tone of voice (Opdenakker, 2006), that a written response cannot. This eliminates potential errors that may come from analysing vague written responses that are left to the interpretation of the researcher.

However, there can be a negative effect of synchronicity: participant bias. This bias is a branch of interview bias, where due to some incentive of the participant or the interviewer, a response is falsified (Williams, 1964). Participants can become aware of what the researcher is hypothesizing or aiming to (dis)prove, and so consciously or unconsciously adapt their behaviour to fulfil what they believe the researcher wants to see. Hence the data collected will not be a true representation of what is being investigated. Participant bias can be reduced by keeping aims broad for participant information and not disclosing any personal aims or predictions. Open questions and broad discussion points can also be used to encourage participants to share whatever they want rather than directing them to a particular goal.

This study aimed to gain and compare the opinion of participants from a large geographical spread, so that the conclusions and recommendations being drawn could be applicable to many different universities. However, typically, comparison can be difficult from qualitative research because everyone's experiences and opinions are unique to them. The broader the discussion topics and the more freedom participants have to speak, the less likely that multiple people would bring up similar topics, making it harder to compare answers between participants in order to achieve the aim of the research. On the other hand, in order for the research method to be applicable to many different people, the questions should not be too structured or specific either. The semi-structured interview provides a balance. It offers direction for the researcher to follow by the use of pre-determined questions, allowing

for repetition in the method for generalisability, and comparison between participants' answers. Yet it also allows participants the freedom to say whatever they deem important, producing rich detailed data. Hence it was deemed to be the most appropriate form of interview for this study.

3.3.3   Focus Groups

A variation of the interview is the focus group: group interviews, consisting of an average of six to eight participants, usually linked by a trait that is being explored, discussing a particular subject pre-determined by the researcher. The topic of discussion is most frequently explored via a list of questions or topics presented to the participants, similar to the interview (Wilkinson, 1998). Focus groups are often used to explore how a particular group of individuals, in this case students currently enrolled at universities supplying some form of academic support, are affected by or have an opinion of a particular subject.

Interviewing multiple people together allows for a greater number of participants to be interviewed in a shorter period of time (compared to individual interviews). The influence of having other participants around and listening to them share their thoughts can encourage others to share their opinions or inspire ideas they had yet to think of. Their presence can also make the process less daunting than a one-to-one interview, encouraging more natural responses. However, this also runs the risk of participants being led into agreeing with the opinions of others, bringing up something they would not have usually. To help mitigate this, the focus group facilitator can encourage participants to take turns speaking first and follow up questions or prompts can be used to get participants to explain their opinion further if they expressed their agreement or disagreement without elaborating.

Alternatively, participants could also be afraid to reveal their opinions because of the pressure of talking in front of other people due to social anxiety or fear of judgment for instance. Quieter participants could be overshadowed by a contributor who has taken a dominant role in the group discussion, using up the majority of the time to share their opinion rather than let others speak. This is where the role of the facilitator is particularly important, keeping note of who has spoken and encouraging (but not pressuring) the quieter participants to share their opinion by asking them directly if they would like to share. Icebreaker activities can also be incorporated to encourage everyone to engage from the beginning and help them feel more comfortable in that setting. Activities where each participant has to share something can be particularly beneficial for easing them in to sharing an opinion in that setting, creating a post-it note wall for example.

Focus groups were chosen to interview students as the population to sample from is much larger than that of MSS practitioners. Hence, in order to achieve generalisable conclusions many students needed to be interviewed which would be very time consuming if conducted on a one-to-one basis. The focus

groups were also semi-structured following the same reasoning discussed for interviews in the previous section (Section 3.3.2).

3.3.4   Observations

Glazier (1985) defines an observation as '*an event or series of events observed in its natural setting and recorded by an independent researcher'* (Glazier, 1985, p.105). This method can fit into the positivist and interpretivist paradigms and be quantitative or qualitative research respectively (Costa, 2020), depending on how the observation is conducted: structured or unstructured. The structured observation records physical and verbal behaviour via a list of pre-determined behaviours, making it pre-planned and measurable, dependent on how well the behaviours have been defined. The observer must make a judgement about whether the pre-determined behaviour took place. Then binary data can be recorded for the presence or absence of certain behaviours, and in some instances frequency data can be collected for how many times a behaviour is displayed. Unstructured observations on the other hand focus on cultural behaviour and have no pre-conceived ideas of what behaviours may be observed. The collected data is often in the form of written or verbal notes made as the behaviours occur (Mullhall, 2003).

Observations are used to study participants in their natural environment. They can be conducted overtly, where the participants are aware they are being observed. Often the researcher conducts a non-participatory observation, where they are not involved in the observation activity, making their intentions known and fully informing the participants, and views the scenario from an outside perspective. Conversely, observations can be conducted covertly, where the participants are unaware that they are being observed. Here, the researcher could choose to be involved in the activity being observed, conducting a participatory observation where they actively partake in the scenario being observed (Costa, 2020).

Both methods have advantages and disadvantages. Having the participants in a familiar environment, unaware they are being observed, can eliminate potential influences from controlled environments. These can be influences such as participant bias as discussed in Section 3.3.2, or observational bias or the 'Hawthorne effect' (Kurtz, 2017), where participants' natural behaviour changes unconsciously because they are aware that they are being observed. When participants are unaware that they are being observed, the behaviour being observed is likely to be more natural and therefore this increases the validity of the data generated. However, ethical challenges can arise when deceiving participants, and particularly when achieving participant consent. Overt observations allow participants to give their fully informed consent but are then more susceptible to participant and observation biases. Observations can also be subject to selective observation, where the researchers' own biases can influence what information is recorded, or how situations are interpreted. This can be managed by using multiple observers, or the single researcher practising critical reflection (Johnson, 1997).

The aim of conducting observations in this study was to compare pedagogy of tutoring in-person to that of online. Due to the subjective nature of observational data, comparability can be hard to achieve. The structured observation allows for a checklist of behaviours to be designed before-hand and used for each observation, allowing for that comparability both between environments and participants. Observations were overt in order to be more ethical and not deceive participants, so they felt comfortable discussing the session afterwards. Ways to minimise potential participant bias and the Hawthorne effect were explored and are explained in greater detail in Section 6.3.

Details of how these methods were used during each stage of the data collection are revisited at the beginning of the associated chapters. The approach used will be discussed including why the area is being explored; what research questions are being addressed; the data collection process including target populations and sample sizes, and finally what kind of data was gathered and how it was chosen to be analysed.

3.4   Ethics

Ethical guidelines are a set of rules put in place when conducting research that keeps researchers and participants safe from the potential risk of physical and/or emotional harm. There are different codes of ethical practice based on the area of research being practised. The British Educational Research Association (BERA) is the association guiding educational research in the UK and provides the professional code of ethical practice that is followed for this research (BERA, 2018). Ethical guidelines are particularly important to follow here as human participants are directly involved.

All data collection for this study has been granted ethical approval by Coventry University's Research Ethics Committee. When any changes to data collection procedures that had already received ethical approval were required, an ethical amendment was also granted.

At any stage of the study, when new participants were to be recruited, it was important to ensure they were fully informed about the nature of the study and what would be expected of them. Participant information sheets were provided, either via a link on the first page of the online questionnaires or emailed / given directly to the participant when conducting interviews, and focus groups, and observations. The information sheets also detailed any potential risks of the data collection. This is particularly important as this study reflects on issues indirectly related to the COVID-19 pandemic, which can potentially be a very distressing topic for individuals. Participants were informed that the content would not directly be about the pandemic, but they could withdraw if discomfort arose and were recommended to contact support services.

At all stages of data collection, participants were made aware that they had the right to withdraw, with no reason necessary nor any repercussions. Where possible, for example in interviews when the identity

of the participant was known, the data would then be removed. When data collection was fully anonymised, participants were made aware that their data could not be removed due to not being able to identify their answers.

Particularly for the student perspective stage of this study, anonymity was important, along with providing the opportunity for students to volunteer for interviews and focus groups, where they would no longer be anonymous, rather than directly asking them. This is due to the nature of 'support'. Asking for help can be a challenge for many individuals, so by ensuring anonymity, it would hopefully encourage as much honesty as possible from students, without any fear or embarrassment that they may be identified. Hence all questionnaires were fully anonymised, with no personal data collected. Where participants provided email addresses to be contacted at a later date, it was ensured these were separated from survey responses before data analysis so the participants could not be identified. When asking this of students outside of Coventry University, they were encouraged to email one of the researchers associated with this study who did not have access to the survey responses, so their registering of interest could not be paired to their survey response.

Finally, at all stages, participants were required to give their consent to participate before continuing with the research. For surveys this was achieved by a compulsory consent question on the first page of the questionnaire, where participants could not view the questions of the survey had they not completed it. For interviews, focus groups, and pedagogy observations, an informed consent form was given directly to the participant, which required completion and returning. For general environment observations, informed consent was achieved through an information poster notifying the participants to sit in a specific area of the room if they consented to being observed, allowing support to still be accessible if students did not want to partake in the study (explained in more detail in Section 6.2.2). Ethics approval certificates can be found in Appendices 10 to 12.

3.5   Data analysis

Data analysis can be approached in two ways. A deductive approach stems from an already established theory, which is used to develop hypotheses that will be tested via the data collection in the research study. A research design is created based on testing of those hypotheses (Wilson, 2010). Conversely, an inductive approach is where hypotheses are not created before data collection to be proven or disproven, but instead theories are generated from the data itself, letting the data guide the analysis (Strauss and Corbin, 1998). As this phase of the study is collecting opinion-based data, it is important to be objective and not influence results based on any pre-conceptions or ideas a researcher has. Therefore, an inductive approach has been used.

Quantitative data has been summarised using descriptive statistics, namely simple quantitative measures: percentages, ranges, means and medians, and visual summaries: graphs and tables.

Descriptive statistics helps display raw data in a relevant way in order to better understand what data you have. Tables and graphs can be used to organise and present the data to gain a comprehension of the underlying data, to start to understand its properties such as distribution, central tendency, dispersion, and relationship to other variables. This is where potential patterns and relationships that may be present within the data can begin to be identified (Brown Breslin, 2020). All graphs have been created using Microsoft Excel. Some inferential statistics, namely hypothesis testing, has been used to explore relationships between variables in the data. Inferential statistics are used to draw conclusions about a wider population from the sample being explored (Marshall & Jonker, 2011).

All qualitative data was analysed with a general inductive approach as described in Thomas (2006), which is the process of identifying underlying ideas in raw textual data by grouping evidence together into distinct themes, similar to that of thematic analysis (Braun & Clark, 2006). As described above, this approach was used to allow ideas to be formed from the data rather than to fit any pre-conceived hypotheses. The guidelines are as follows:

1) **Preparing raw text data.** Convert all text into a common format, for example, font, size, or removal of interviewer comments.
2) **Reading the text closely and repetitively.** Repeatedly read the text until one is familiarised with the content of the data and recurring ideas have begun to be identifiable.
3) **Creating the categories.** Derive categories or themes based on the recurring ideas within the text. Upper-level categories are influenced by research aims, and lower-level categories are a result of repetitive reading.
4) **Overlap and un-coded text**. Due to the nature of qualitative data, multiple responses can be coded into the same category and significant portions of text can be irrelevant and so not coded into any category. The same response can also be coded into multiple categories.
5) **Refinement.** Look for possible subgroups within the defined categories, to provide more information, including contradictory points of view. Extract quotes from the text that are clear examples of each of the categories.

Details of the specific data analysis conducted for each phase of exploration are discussed in Sections 4.3, 5.3, and 6.4.

3.6   Limitations

When reflecting on the methodological design, it is important to identify any limitations, and address what impact they could have, and if possible, how they could be reduced. This section considers general or overall limitations of the study as a whole. Specific limitations of design, collection, or analysis, for each stage of the study are discussed in Sections 4.5.1, 5.5.1, and 6.7.1.

This study looks at MSS both inside and outside of the UK. However, an international outreach to countries that do not speak English is limited as this would require additional assistance translating materials into other languages and back again into English for analysis. However, due to language differences, this can result in a loss of meaning in answers, which could be particularly detrimental as the data being collected is opinion-based data and would therefore influence the results. Therefore, international countries that can use the materials of this study without a translation, with the exception of a collaboration with German practitioners who provided translation (discussed in more detail in Section 4.2.3), will be sampled in the study.

The framework for the good practice of MSS in the new normal was designed based on the key findings from this study. However, due to the limitations such as pandemic restrictions, time, differing university schedules and procedures, and language barrier as discussed in an earlier point, the number of international responses within the data are limited. Hence, the framework will be more highly influenced by data from within the UK and Ireland, and so may not be as generalisable to institutions further afield. Therefore, to limit this effect, it will be important to consider key findings that are significantly present in both the UK and international data.

3.7   Summary

In this chapter, relevant research approaches and data collection methods were discussed and evaluated. After providing an overview of the study, including the research questions under investigation, research philosophies and methods were described and justified as to why they were chosen to be used in the context of this study. Three key phases make up the study and how these data collection methods were used specifically during each stage will be detailed in Chapters 4, 5 and 6. All three phases helped inform the final goal of the research study, to make informed recommendations for good practice in MSS provision in the 'new normal'.

4 The practitioner perspective of online Mathematics and Statistics Support

Phase one of this PhD study was a longitudinal exploration, across three sampling points over 13 months, into the thoughts and opinions of practitioners on the move to online MSS that occurred in the early stage of the pandemic. The sampling points were May 2020, January / February 2021 and June 2021.

The first section describes the overall approach taken during this phase of the study, explaining the decision made to have practitioners as the initial focus, as well as setting out the research questions associated with this phase. Section 4.2 explains the specific methodology used for each sampling point, with the rationale behind the choices made, and the data collected at each point in time is discussed. The subsequent section (4.3) describes the analysis that was undertaken on both the quantitative and qualitative data collected, followed by key results from each investigation point reported in Section 4.4. Section 4.5 offers a discussion of the findings and as well as an overall look across this phase, with a comparative look at other works in this area of exploration, before evaluating any limitations identified. Finally, a summary of the key points of this chapter is provided in Section 4.6.

4.1 The approach

In this first phase of exploration, the opinions, and perspectives of those directly responsible for having to transition MSS provision to an online setting during the Covid-19 pandemic were chosen as the focus. As the pandemic, and hence the transition in provision, was sudden and unexpected, it was important for practitioners to be the subject of this first phase. This is because, for many, online support was a new challenge. As new provision methods were being trialled and improved over the progression of the pandemic, new opinions were being formed, and the reasoning behind decisions made could be explored as MSS practitioners navigated a new territory.

This phase is relevant to research questions RQ1 and RQ2. These questions aimed to explore what mathematics and/or statistics support methods institutions in the UK and the rest of the world offered prior to and during the pandemic (RQ1), and to gauge what practitioner opinions of online MSS provision were at the start of the pandemic, and how those changed as it progressed (RQ2).

In order to give context to those opinions, knowledge of what was being provided both prior to and during the pandemic was required before opinion of online MSS could be collected. In order to answer RQ2, a longitudinal approach was used, exploring what the current MSS practitioner opinion was at three separate sampling points over 13 months of pandemic restrictions. Responses from participants could then be compared to see how opinions had changed over this time.

4.2   The Data

The following section details what data was collected at each sampling point and what methodology was used to acquire it.

4.2.1   May 2020

The first sampling point was May 2020, two months after the UK was first sent into a nationwide lockdown. It was important to collect a sample at a time when online support was very new, and opinions were influenced by a crisis reaction, to offer a baseline for comparison.

The sample came from primary data collected by Hodds (2020a), who used an online questionnaire with Jisc Online surveys, and ran it alongside the **sigma** Network's first online workshop. The survey received 119 responses in total, from 73 individual institutions across the world: mainly in the UK (53), but also 11 in Ireland, six based in mainland Europe, two from the US, and one Australian institution. Information was collected on what provision institutions offered prior to the pandemic, including any online support planned to be offered, which was then compared to what they were offering at that moment, in the very early stages of the pandemic. Potential concerns were also explored, such as any difficulties faced, students seeking online support for questions they were being assessed on during exam periods, and student engagement.

Results of this study were published the following month. However, there was a final open-ended question on the survey and practitioners' responses to this were not included in this initial analysis. The question was as follows:

> *"Should delivering maths and stats support online change the nature of our approach? One way to approach online maths and stats support is to look for ways to replicate as best we can the way we give support when working face to face. Is this the best way to approach online maths and stats support or should we be adopting different approaches for online support? If so, what approaches?"*

It generated 74 free-text responses, and these were analysed for the first sampling point in the current study.

4.2.2   January and February 2021

The early months of 2021 were the second sampling point, where 12 practitioner interviews were conducted. Interviews were used to gather richer, more in-depth qualitative data, without being limited by aspects such as structural constraints and character length, as free text responses in questionnaires sometimes are.

This sample was gathered at a time after many practitioners around the world had had a break, (at the end of the academic year) allowing time to reflect on their initial response to the pandemic. The next academic year then brought them the chance to implement a more considered approach to online MSS during September to December 2020. Therefore, it was felt that opinions would not be as influenced by the sudden and unprepared for change, as practitioners had had time to think about potential solutions to any challenges they experienced. Participants were selected from those who had registered their interest to partake in future research when asked in the May 2020 questionnaire. These were then narrowed down to 11 participants, ensuring they covered a wide range of locations, namely England, Ireland, the Czech Republic, and Australia, and (within the UK) institution types, for example, Russell group, post-92, and online-only universities. An additional participant was recruited from Coventry University as a trial interview and was later decided to be included in the data set.

The interviews consisted of 10 pre-determined questions (see Appendix 1), following a semi structured design. This allowed for the set of open questions to be given to all participants in the same order, giving the interviews direction, and allowing for comparison between participant answers. However, it still allowed participants to not be restricted in the response they gave and speak freely to share anything they wanted to, even if it was not directly asked by the interviewer. There was also room for the interviewer to follow up on any participants' answers for further detail where required.

When designing the questions, there were three main purposes: to gain an understanding of what was being offered at the participants' institutions (questions 1, 3, and 4); to gauge an idea of their opinion of both current and future provisions (questions 1, 2, 8, 9, and 10); and to explore student engagement (questions 5, 6, and 7). All questions were open to ensure the participants could provide as much information as they pleased. The 10 questions were originally piloted on one practitioner, to test the functionality and flow of the interview questions and identify any needed clarification or re-wording. However, the interview was chosen to be included within the data set as it was so successful, and the questions did not require any modification.

Each interview was video recorded using Microsoft Teams, strictly for the creation of a transcript. However, at the time the interviews were conducted, MS Teams did not have a transcript function. Hence to generate a transcript from the recordings, the videos were temporarily uploaded privately to YouTube to generate and download a transcript and then removed. Once the videos had been used to make any edits required to the transcripts, they were deleted. Interviews ran between 30 minutes and 1.25 hours.

4.2.3   June 2021

The third and final sample was from a survey conducted in collaboration with a team of German MSS practitioners. Not only was this survey used to complete this longitudinal exploration and gauge what

the current practitioner opinion was just over a year from the initial sample, it also had an additional purpose. This was an opportunity to gain a more focused look at MSS outside of the UK and compare opinions from practitioners based in Great Britain & Ireland (referred to from here as GBI) to the opinions of MSS practitioners working in Germany, as MSS in Germany is relatively new compared to provision in GBI.

Both surveys were developed and distributed online. Jisc Online surveys was used to create the English version of the questionnaire. The questions were first designed by the German practitioners based on those that were asked in the Hodds (2020a) survey, and the interviews conducted at the second sampling point in this study. This allowed for strong points of comparison to the previous samples. They were then translated into English before being sent to the UK team to review. Moderate changes were then suggested, and the following were adopted by both questionnaires:

- More precision in comparison questions by the use of dates, particularly because university semesters run differently between institutions
- Using 5-point Likert scales, to include a middle neutral option and remain comparative with the first sampling point in this study
- The removal of a repetitive question
- The addition of asking for an institution name and a completely open question at the end of the survey allowing the opportunity for participants to provide any additional comments

There were also some differences between the two questionnaires, which will now be discussed, but it was decided this would not affect comparability. For the GBI survey, the translated English was modified for flow and understanding, and to better fit the structure of MSS in GBI. Some initial demographic questions on the German survey were not included for the GBI questionnaire, as the UK team felt it was not necessary for them to collect that information. Additionally, question 28 of the survey, although asking the same thing, is in a different form for both surveys (see end of Appendix 2). It asked respondents their institutions' plans for the future in terms of what provision they will be providing, namely in-person only, online only, a mix of both, or "other". In the GBI version, respondents were presented with these options as a list from which they could only select one as they were all intended to be mutually exclusive. However, in the German survey, respondents were given these as statements, for example '*we plan to return to fully face-to-face provision*' and asked to respond 'Yes' or 'No' to each one in turn. This was because they had an additional option of '*provide online workshops*' that was not mutually exclusive to some of the other options. This was identified as a limitation to this study and is discussed in more detail in Section 4.5.1.

The questionnaires consisted of 32 shared questions, with the German survey containing three additional questions gathering respondent information. They were broken into 10 Sections exploring

different areas of MSS, specifically: questions about the respondents' mathematics learning support centre (MLSC), engagement, advertising, technical issues, handling digital media, interaction, effort, time, returning to face-to-face, and final comments. Grouping questions this way kept the structure and flow of the questionnaire simple and more manageable, particularly as the questionnaire was reasonably long. Of the sections listed above, engagement to time were all areas of concern that were brought up in the Hodds (2020a) survey, and hence explored again here. Excluding the consent statement at the beginning of the questionnaire, all questions were non-compulsory except when the option 'other' was chosen where they were then required to specify.

The questions were a mix of single or multiple-choice answers, free text response, and scale questions. By using a variety of question types, the questionnaire produced both quantitative and qualitative data. Questions collecting quantitative data were used to gather information on what institutions offered during this stage of the pandemic, as well as their level of agreement with statements about a range of different phenomena to compare to the previous samples. Open questions collecting qualitative data were used to get the practitioners' own perspective on how their opinions of online MSS have changed and associated advantages and disadvantages and give them an opportunity to discuss elements of online support that were not questioned in the survey.

The majority of the questions on the questionnaires were Likert Scale questions (22/32) that, as mentioned above, used a five-point scale to match the Likert Scale questions used in the Hodds (2020a) survey. This was because Likert Scales can quantify opinion in a numerical form that is easily recognisable and can then be more easily compared as opposed to free-text responses (Basias & Pollalis, 2018). However, this did result in a risk of participant bias, as discussed in Section 3.3.1, where the answers could be selected without thought. Most of the questions used the same scale, for instance, questions 8 to 16 and 19 to 27 are questions measuring agreement, using a strongly disagree to strongly agree scale, which as opinion is being explored, was the most appropriate scale to use. However, questions 17 and 18 measure usage using a different scale type. This sudden change provided different options to choose from in the aim to re-invoke any concentration lost.

The call for participants for both surveys was via email using either self-registered lists of MSS practitioners (the **sigma**-network Jiscmail list for GBI and a newly established network of German MLSCs for Germany) or, forwarded directly to contacts. The German survey ran from April 7th to April 30th, 2021, and the GBI survey ran from the May 21st to July 9th, 2021. Due to variation between both the institutions involved, such as differing academic year schedules, varying ethical requirements, and past data collection, both teams chose a time that they felt was more likely to gather the most responses from practitioners. This period of April to July was deemed a relatively stable time, so the difference in distribution periods was concluded to have limited influence on the responses received.

4.3 Data Analysis

The following section details what data was collected at each sampling point and the data analysis that was conducted on each.

All qualitative data was analysed using the general inductive approach as described in Section 3.5. The specific process and any additional considerations that were made for each data set are described in the following subsections. As this was the first time the researcher was conducting this form of analysis and the data set was of a manageable size, it was decided to perform it by hand using Microsoft Word, instead of using software such as Nvivo. This way each step could be learned, processed, and familiarised and the reasoning behind the selection of themes and the choices that were being made could be fully understood and rationalised.

Quantitative data was summarised using descriptive statistics, representing the data as bar graphs and tables where appropriate to better present the data.

4.3.1 May 2020

After discounting any blank entries, the final open question of the Hodds (2020a) survey received 74 free-text responses ranging from one to 179-word answers. All of the responses were collated into one document, formatted into the same font and size, minimally corrected where necessary to aid reading (such as adding in or removing spaces and correcting obvious spelling mistakes), and assigned a number. These were then read repeatedly.

To begin generating themes, for each response the key idea(s) or opinion(s) within that response needed to be understood. Key words or phrases were useful in then recognizing these ideas that were shared between the responses. A colour and a general name or broad description, such as 'do not replicate', were then given to these general ideas and the associated quote highlighted. Gradually, links could be established, and responses could be grouped into these loose themes.

Once the responses had been sorted into at least one group, the broad categories were then refined, revising the names and descriptions given, and segmenting them into subgroups where applicable to provide additional and more detailed information. For instance, using the example above, the category 'do not replicate' could be split into specific reasons as to why practitioners felt that we should not be replicating in-person techniques in an online setting. It was also common for practitioners to convey more than one key idea within their response, as is the nature of free text questions, and so many responses could be coded into multiple themes.

As qualitative analysis is subjective and can be easily influenced by a researcher's own biases, two researchers independently analysed the raw text data without seeing the work of the other. Both produced their own set of themes and coded responses which were then compared to assess the

trustworthiness of the generated categories. A high level of overlap was identified increasing confidence of the validity of the results. With the creation of one additional category and agreeing where each response should be coded to, both sets were merged to produce a final list of the key ideas, discussed in Section 4.4.1, that practitioners had about how we should be approaching online MSS in May 2020.

4.3.2   January / February 2021

There was significantly more data to be analysed in the second sample which contained 12 transcripts with lengths ranging between four to 11 pages of textual data after editing.

Firstly, answers given for each question of the interview were summarised. Each question was written with a purpose to explore specific information; hence it was important to summarise what key points were generated from each. This was analysing the information that was a direct result of the question.

For discovering the discussion-generated themes, the interviews were then explored as a whole piece of text following the general inductive approach (Thomas, 2006). The same procedures were followed as detailed in Section 3.5, however some extra considerations needed to be made that will now be discussed.

The use of the search tool for key words and phrases, and their potential synonyms, was crucial in the identification of shared ideas for this type of data. This is because of the nature of interviews; a large quantity of the text was not going to be coded into any group and therefore required searching through. This was also used as a way to check if any mentions had been missed and also aided collecting the frequency.

If a participant discussed a specific point, diverted to discuss something else, and returned to the original point later on, these were considered to be separate mentions and so were counted twice. Additionally, if several ideas were mentioned altogether but could all be linked under a broader overarching theme, they were also classed as multiple mentions (for example, 'not being confined to a room' and 'offering more time slots for support' could both be linked under the umbrella 'flexibility' but are two separate ideas and therefore two mentions of that theme).

For this analysis, it was important not to include the ideas that arose only due to a question being asked. As all 12 participants were receiving the same questions, the same topic would have been discussed by all the participants. Therefore, this repetition between practitioners was forced by the nature of the questions, and therefore ideas shared may not be truly representative of the key concerns or ideas of the practitioners being interviewed. For that reason, it was necessary to distinguish between ideas that were brought forward only as a result of a question, and those which arose naturally during the discussion. Hence, ideas were only classed as themes if they had been repeated by practitioners at various times throughout the interview, or at different points across the interviews, not just only in response to a single

question. It is important to note however that it was common for participants to naturally mention topics that were the subject of later questions, therefore there is some overlap between themes and interview question topics. Nevertheless, it was important to also include a summary of practitioner answers for each question, so that information only shared during a particular question was not lost.

Both the number of times a concept was mentioned and how many practitioners raised that idea were taken into account when deciding if it should be considered as an overarching theme. This was important in order to prevent potential skew created by more talkative interviewees, without losing the impact of the issues that were most important to only a small number of the participants. For instance, if a single participant mentions the same idea multiple times, it would suggest that it is a main concern for them, and so only quantifying it as 1/12 participant mentions would lose this impact. On the other hand, if only frequency of mentions is looked at, for this example, although seemingly mentioned many times, if it is only mentioned by one participant and no one else, it is not likely to be a generalised concern for practitioners. Hence why it was crucial to look at both frequency types. Which theme was mentioned the most by each practitioner, and therefore considered as their highest concern, was also explored.

After the first refinement and creation of subcategories, there were 20 identifiable shared ideas about online MSS by the 12 participants. These ranged from having been mentioned by all, to only mentioned by four. It was then decided that only themes mentioned by eight or more participants (a majority) were then considered to be overall themes, to establish an idea of the main concerns shared during the interviews. Therefore, they were further condensed down, either by merging ideas together as subcategories under one shared theme or removing those that were least mentioned. The final eight themes are discussed in Section 4.4.2.

4.3.3   June 2021

For the purpose of this longitudinal study, the data and analysis being discussed here is from the GBI survey only.

The GBI survey received 35 respondents from 24 individual institutions, 17 in England, three in Scotland, three from Ireland, and one from Wales. However as mentioned earlier, all questions were not compulsory and so each question had a varying number of responses.

Descriptive statistics were used to graphically summarise the quantitative data that was produced from selected questions. As there were many questions asked, those that best answered the research questions were selected. Bar graphs were chosen to present this data as these were the most suitable representation of the Likert scale data. Using these graphs makes it easier to visualise relationships in data sets and compare multiple sets of data just by looking at them.

Once blank entry answers were discounted, not including responses to the additional comments question, a total of 74 free-text responses were received across the three final open-ended questions on the GBI questionnaire. These were analysed using the same procedures and considerations as described for the May 2020 sample (see Section 4.2.1).

4.4 Results

The following section details the key results identified at each sampling point.

4.4.1 May 2020

Provision

With a view to addressing RQ1, exploring what institutions offered prior to and during the pandemic, key findings of provision identified and reported in the Hodds (2020a) survey will first be summarised. This will act as a point of comparison for the remaining two sampling points.

In the Hodds (2020a) survey, respondents came from 53 UK institutions, 11 Irish institutions, and eight institutions from the rest of the word (ROW), namely Australia, Czech Republic, Germany, Norway, and USA. Prior to the pandemic the most common forms of MSS provision were offered in-person. 70% of UK institutions offered drop-in, appointments (described as face-to-face one to-one support), and workshops. All 11 Irish and six (75%) ROW institutions offered drop-in support. For appointments, eight (72.7%) and six (54.5%) Irish institutions offered ones for mathematics and statistics respectively, as did five (62.5%) and four (50%) ROWs. Finally, five (45.5%) Irish and five (63.5%) ROWs offered workshops as well.

For online support this was a lot less. The most common method was for UK institutions was email support, with 39/53 (73.6%) institutions offering it. A third offered online appointments for either mathematics or statistics and only two provided an online drop-in service. For outside the UK, online drop-in and appointments were only offered by one (9.09%) and four (36.4%) Irish institutions respectively. For ROW institutions, online provision was mainly videos or emails, each offered by 50%.

After the pandemic, 50/53 (94.3%) UK institutions offered some form of online support. Much more commonly was the provision of online appointments, 40/53 (75.5%) for mathematics and 34/53 (64.2%) for statistics, compared to the 18/53 (34%) who offered drop-in. Comparatively for outside the UK, drop-in support was the focus, with three (27.3%) Irish institutions offering drop-in to only one (9.09%) offering either mathematics or statistics appointments. For ROW, one (12.5%) institution offered drop-in, and one offered workshops.

Open question analysis

As a result of the general inductive analysis performed, seven thematic groups were identified from the 74 free-text responses to the final question on the Hodds (2020a) survey. Tables 4.1 and 4.2 display the percentage of responses that were categorised as being within each theme.

Three categories were question-generated themes, shown in Table 4.1, which Thomas (2006) describes as upper-level or general themes that were a result of the aims of the evaluation. Hence in this context, they arose as direct answers to the question that was asked, namely, do or do not replicate face-to-face support in the online setting, and those that could not answer.

Themes		%	
		Of theme responses	Of the 74 responses
Do Not Replicate	Too Difficult	53.8 (7)	17.6 (13)
	Online has its own benefits	30.8 (4)	
	No reason given	15.4 (2)	
Replicate	Face-to-face is superior	33.3 (4)	16.2 (12)
	No reason given	66.7 (8)	
Cannot answer the question	Unsure	79.2 (19)	32.4 (24)
	Need further research	20.8 (5)	

Table 4.1 *Question-generated themes identified in the May 2020 open question data. The Table displays both the percentage of all responses in each theme, as well as the breakdown of the subgroups within each theme. The number in the brackets are the absolute number of responses.*

It is important to note not all 74 responses fit into these three categories, as some respondents did not state their opinions of replication, and neither did they state that they were unsure, instead focusing their answer on the other parts of the compound question or taking the opportunity to talk about anything they deemed important to mention.

Each of the question-generated groups could also be further broken down into the common reasons why respondents answered as they did. These reasons will now be discussed in more detail.

Do not replicate

The consensus of this category, containing 17.6% of responses, was that the respondents felt that face-to-face support methods should not be replicated online as they are two very different settings with their own strengths and weaknesses. More specific rationale included the difficulty of replication due to these differences, often wasting time and resources trying for replication and still not achieving the same result, or not being able to achieve full replication in the first place for lack of know-how or resources. Some also stated that online support has its own benefits and that simply replicating previous methods would not utilise them, particularly regarding access and availability. One respondent stated, "*I think it's very difficult to always replicate online what we do face-to-face ...*", with another describing "*... we don't need to worry about venues, we could offer* [online] *tutorial support to students on much more regular basis ...*". This category also includes two respondents that did not give a reason why they thought we should not replicate.

<u>Replicate</u>

In the opposing argument, only slightly fewer practitioners (16.2% of responses) felt that we should be replicating in-person support methods online, as in-person methods have already proven to be successful. Some responses went further and stated face-to-face methods are better than an online approach. Responses included "*we should aim to replicate as best as we can our approach when working face-to-face*" and "*Face-to-face teaching remains priority*".

<u>Cannot answer the question</u>

Some practitioners felt they could not give an answer at the time of the survey. This was the most common direct response to the question, receiving 32.4% of the total responses. This group breaks up into two main rationales as to why they could not answer the question: those straightforwardly unsure ("*I'm unsure what to say to this one*"), and those requiring more research in this area before being able to decide or give an opinion ("*Not enough is known but research like this will help*"). This category also included the one respondent who stated they did not understand the question.

The remaining four themes were discussion-generated, meaning they arose naturally because of the open-endedness of the questions where respondents were able to say whatever they thought relevant without a specific prompt. Thomas (2006) describes these as lower-level or specific categories that have been identified as a result of repetitive reading of the data. It should be noted that, due to their compound nature, some responses are categorized into both one of the three themes described above and one of the four themes described below, whereas others only fell into either.

Themes		%	
		Of theme responses	**Of the 74 responses**
Blended approach	Physically blended	71.4 (5)	9.5 (7)
	Blended methods	28.6 (2)	
Trying things out			6.8 (5)
Open to new approaches	No reason given	45.0 (9)	27.0 (20)
	Lacking better methods	30.0 (6)	
	Online is better	25.0 (5)	
Looking for the best option			21.6 (16)

Table 4.2 *Discussion-generated themes identified in the May 2020 open question data. The Table displays both the proportion of all responses in each theme, as well as the proportion breakdown of the subgroups within each theme. The number in the brackets are the absolute number of responses.*

<u>Trying things out</u>

Some answers (6.8% of responses) described methods or adaptations that respondents were currently trying but were unsure about how to progress or, had tried and having not been successful were unsure what to do next. Although only containing five responses, making it the smallest category, this was still included as a theme as it can be a useful benchmark for seeing how methods have improved. Two responses were a description of how communication barriers in an online setting were being overcome, *" ... it is a good practice to re-write the last equation or last two lines of the analysis on the new page to help with continuation of the discussion when providing online support"*, and three related to issues practitioners were facing in new support methods, *"tutorials revolved more around 'how to be successful in an online class' than around mathematics concepts"*.

<u>Blended approach</u>

During the discussion between the two coders, it became clear that there were two different definitions of a 'blended approach' in practitioners' answers, and this category, containing 9.5% of total responses, encompasses both.

Most responses in this category described a blended approach as having online support methods running alongside in-person face-to-face MSS at the same time, *"we can support students both face-to-face and online"*. However, two described a blended approach as being wholly online, but utilizing a combination of recreating face-to-face methods, while also introducing some new online methods, *"a mix of replicating the way things are done face-to-face and trying to find new ways of doing things"*. Responses mentioning a blended approach generally recognized that both formats had their own strengths and weaknesses, but rather than choosing one over the other, suggested that a combination could utilise both, providing a range of benefits, particularly in respect of access to support.

<u>Open to new approaches</u>

This category contains 27% of responses, all of which suggest the practitioner is currently leaning towards a side, either replication or non-replication, but is not 100% fixed on their opinion of which direction we should go, and so is still open to new approaches. *"... we should be replicating face-to-face teaching, but just like in face-to-face, we should keep an open mind about ways to improve the support"*. This category can also be broken down into sub-groups providing additional information as to why the respondent is open to new approaches. A regular similarity, mentioned by six different respondents, was stating that they were recreating face-to-face methods for lack of better methods and that this was not proving successful and so were looking for a better approach. Examples include, *"At present we are replicating face-to-face for want of better methods"*, and *"... we tried to replicate as best we could our existing services. However, student engagement was low"*. These responses were not included in the replicate category as it is clear that the practitioners do not feel this is the best approach and are open to alternatives. Also included in this category are statements claiming online methods are

better than in-person and that we should be moving support online anyway. These responses are clearly open to new online approaches but did not give a lot of detail about how, "*we should continue to offer more online support for students*".

<u>Looking for the best option</u>

This final category arose as a result of the discussion between the two coders. It was noted that although many responses stated or implied that they were open to new approaches, the level of certainty differed. Some responses were currently leaning to one side, uncertain of what we should do, whereas other responses were sure that we need to look for the best approach regardless of what direction that may be. Answers placed in this category, totalling 21.6% of responses, often recognised weakness on both sides and so were neither for nor against replication, resulting in being open to all potential methods. A key phrase identified for this thematic group was wanting enhancement and/or improvement, without indicating where this enhancement might come. Practitioners were generally in agreement that the goal of MSS remains the same regardless of the form it is in, and therefore we should be looking for the best methods regardless of the setting. "*All options should be explored, different approaches work with different students*", and simply, "*It will adapt—the goal remains the same*".

4.4.2   January / February 2021

The January / February 2021 interviews consisted of 10 questions asked to 12 participants, generating transcript data ranging from four pages to 12 pages per participant. The following subsections provide a summary of practitioners' responses to each question asked, followed by a description of the underlying themes generated from exploring the interview transcripts as a whole.

4.4.2.1   *Summary of interview questions*

<u>What online Mathematics and Statistics support is your institution offering?</u>

All 12 participants were offering some form of online support at the time the interviews took place. One explained that there was a small opportunity to provide in-person support between lockdowns and that there were some students on campus, however many stated they were solely online at this point, with one institution in summer break. The most common support provision, with nine practitioners (75%) stating they offered it, was bookable one-to-one appointments. This was closely followed by eight practitioners (66.7%) offering group tutorials or workshops, either scheduled, or on request of students. In addition, five (41.7%) also offered an online drop-in service following a timetable of specific hours. Other less common support provisions being offered included providing an email or phone service, embedded sessions within subject departments, and forum support. One practitioner (8.3%) expressed the success of online study groups. This was where two or three breakout rooms were set up for groups of students to work on given problems with a shared online whiteboard, and the tutor would drop into each room and assist if needed. They later went on to share that they felt energised to see students '*arguing together over a problem*' even in this new online setting. Asynchronous provision included

the making of videos or recording delivered workshops, and online resources accessible through a website.

<u>Reflecting on what has happened in MSS since the pandemic, do you see any benefits from the new ways of working that have been introduced. And any disadvantages? Further, have you found your opinions have changed?</u>

The most common benefits provided by the participants were examples of increased accessibility, where online provision had created more opportunity to access support for particular student groups. One group referenced were anxious and less confident students. Practitioners described that an online setting allowed these students to feel more anonymous, particularly when not using a camera, helping to reduce embarrassment for accessing support because they felt they couldn't be identified. *"They would ask me, you know, 'do you, did the lecturers know that we've been here?', 'do other people know the students that are here?'...a lot of students didn't like that they could be seen by other people struggling".* Students could access services in the comfort of their own space, with technology they were familiar with, helping to make them feel more relaxed. Two practitioners (16.7%) said they felt some students actually prefer online support, and it was suggested that these elements encouraged those who may not have accessed support before to do so. Additionally, the ability to connect with remote campuses for multi-campus institutions was highly praised, with one participant explaining uptake of workshops had increased because remote students could now access the service.

Online support allowing greater flexibility closely followed, with practitioners expressing the benefits of working from home and how it can be more accommodating to staff and students alike. There was no longer a requirement to commute to provide or access support. Three practitioners (25%) explained that this also saved them time to do other things such as improving the service, seeing more students, or revising material for appointments, which was another advantage. Students also did not have to travel back to campus if they came across an issue after returning home, or distance learners who struggle to travel to campus can now access support where they once could not. Additionally individual schedules, that for many became increasingly harder to manage during the pandemic, could be worked around. It was expressed that this was particularly important for mature students who often had families and jobs to also juggle with their education. One practitioner (8.3%) also mentioned how with online support there is no limit on attendance unlike a physical room.

Other benefits mentioned included the advantages asynchronous material can provide, particularly the repeatability of videos and how students can go over the material at their own pace as much as they felt they needed to. Finally, one participant explained that the transition to online was easier as a statistics tutor, and the ability to work on their own separate devices and share the screen was really useful.

However, there were more negatives shared than positives, the most frequent being loss of social contact and barriers to communication, frequently correlated with students not having their cameras on. The

difficulty in reading the room and gauging if students were understanding, without the use of body language, facial expressions and sometimes even voices was the largest concern as a result. "*You don't know if you should add a sentence, or ask a question, or wait*". One practitioner also highlighted the importance of the '*human factor*' in support, *"part of support is being someone they can trust that's looking out for them, not just a maths educator"*, which they felt was lost with online support. Some felt it was much harder to build relationships with students being away from campus, and also students building relationships among themselves, with the loss of group working being of particular concern.

Another challenge brought up by practitioners was the learning curve to supporting students online, not only in terms of the new technology and software needed but, adapting the pedagogy to support students online successfully as well. However, this learning curve also applied to students, *"we don't want to be teaching people about the system as well as providing support in maths and stats"*. They also found that delivering online support is less efficient than in-person, giving examples such as requiring more staff to deliver and support workshops, having to jump through more hoops to book appointments, and technology issues causing sessions to take longer. The latter of these reasons was further exacerbated by students not having the knowledge to use the required technology, having low quality technology that doesn't work well, or simply not having the required technology at all.

As with the benefit of online support potentially bringing in students that would have not used in-person support, practitioners voiced their concern for the opposite; that there are students that no longer use support because it moved online, with five practitioners stating that engagement numbers were down.

Finally, a subset of disadvantages provided by practitioners could be grouped under the idea that there were elements of in-person support that were harder to achieve online. These included: the challenge of writing mathematical symbols in an online setting; difficulty in sharing work, particularly where students have begun a solution on paper; it being harder to pace sessions when delivered online; that it was more of a challenge to identify the questions being asked about assessed content during online exam periods; and the inability to provide practical demonstrations. Some practitioners stated that more effort and cooperation between both sides to learn and adapt habits was therefore needed for online support.

The second part of this question asked participants if their opinion of online support had changed since the beginning of the pandemic, to which nine (75%) of them stated they had grown more positive. These practitioners explained that with time and practice they had learned more and grown used to supporting students online, and along the way learned that online support is possible and actually has its own positives. *"It* [the pandemic] *has opened my eyes in a work sense... to be open to these kind of things"*. One practitioner praised the fact they were forced online because they would not have done so otherwise; how against it they were beforehand but now recognised how unaccommodating that frame of mind was. Of the remaining three (25%), two explained their opinions had not changed because one

was positive from the start, and the other still enjoyed supporting students just as much. The remaining participant stated their opinions had changed but did not reveal if this was positively or negatively. Additionally, seven practitioners (58.3%) stated they would still be offering some online support alongside in-person support when restrictions allowed, even before they were questioned on it later. However, half the participants revealed they felt that in-person support was still superior, as the disadvantages of online outweighed the advantages, or in-person support could just offer more approaches that online support cannot.

<u>Are there any online methods that you are not currently offering that you would like to in the future? If so, what is holding you back in implementing these methods?</u>

There were not many answers given to this question, a common response being that they didn't know what else was available to offer at this point. An opportunity for peer-to-peer group work was mentioned as desirable, but a particular method to achieve this was unknown. Some practitioners also mentioned an idea they had thought of, or had trialled and found unsuccessful; two for online forums and one for online drop-in.

Instead, many mentioned wanting to improve or offer more of what they were already providing. These included making resources more accessible, supporting students with disabilities better, converting some sessions they used to run in-person to an online delivery, and directing students to quality resources elsewhere such as "Khan Academy" with a view to save time recording their own material. Saving time was also a concern for another participant for when students did not turn up to drop-in sessions, who believed setting up an appointment system and offering more bookable appointments instead of drop-in hours would be more time effective. However, one described that time was holding them back as making improvements to MSS were not as high a priority as other areas impacted by the pandemic.

<u>How are you advertising your online MSS? Do you feel it is successful?</u>

Advertising online MSS was achieved in multiple ways. Many online methods that would be expected were used, such as emails, online pages including Moodle, YouTube, forums, social media, and embedded advertising in delivered sessions. Five practitioners (41.7%) also stated that they utilised broader university communication like newsletters, central social media pages, and the student union channels of communication. Targeted advertising was only mentioned by three participants (25%). They explained that provision advertised to different disciplines were only the services most applicable to them, or that specific times of the academic year were targeted to try and achieve the best result, such as the start of terms or development weeks. Finally, one practitioner also utilised SMS (short messaging service) but on a limited basis due to cost.

Word of mouth was the most common form of advertising, going through lecturers and academic staff in particular, and for some deemed the most successful. "[A lecturer promoting the service] *seems to*

have a much more positive effect than anything else and that's true whether it's face-to-face or online". However, for others, the impact of the pandemic made it harder to transition this to the new online setting. *"...the relationship that we would have had with the course tutors before the pandemic I don't think that's carried over and I think we've missed out on getting the course tutors to advertise".* Students telling their peers about the service was a highly valued advertising method in-person and online. "*You would think your communications were effective because all the students knew about it. In fact you probably only got to 10% of the students and they told the other 90*". However, two practitioners did also state that this aspect (student to student advertising) used to be responsible for a key percentage of engagement with the service, but this was not as effective in an online setting.

When asked how successful practitioners deemed their current advertising to be, there was a varied response. For four (33.3%), they felt it was successful as they were still seeing students accessing support or saw initial spikes after advertisements were distributed. One practitioner explained that the previous semester they did not have the time to put in to creating new advertisement materials, but now that they had, they saw the difference in engagement numbers. However, for the majority, the issue of low engagement still remained, and despite having to repeat advertising many times, there were still students who claimed to not have heard of the service. The concern of information overload for students and academic staff alike, through too many emails, or targeting undergraduate students at the start of the year, was another reason proposed as to why advertising may not be as successful as hoped. It left practitioners feeling like they were doing what they could, but there must be another way of reaching these students. Three participants (25%) were also inconclusive about the success of their advertising, experiencing both evidence of success and frustration, with one explaining that the students had just got used to the new way things were being done, rather than anything the staff themselves did causing this.

How many students are accessing your service? Has this number changed since the beginning of the pandemic and if so, why do you think this may be?

Although many practitioners could not supply exact numbers, rough estimates were asked for so that any change in student engagement since the beginning of the pandemic could be evaluated, and what engagement looked like compared to before support moved online.

All but one practitioner (91.7%) said they had seen an increase in engagement when compared to early months of the pandemic, ranging from a slight to a huge increase, with engagement not dropping off later in the year as much. Three institutions were actually seeing more students than they had ever done before. However, these were not like the others, in that one was a distance institution, where the majority of study is off-campus and online, and for the others the practitioners reasoned this was because their services were becoming more well known. The remaining practitioner explained that they were having issues with a new booking system, and instead had to wait for students to request the service and then contact them by email. Therefore, they thought they were possibly less busy, but felt a comparison was

difficult to make. Some hypotheses as to why engagement with MSS was higher than in the early stages of the pandemic included that students were finding things harder due to the influence of the pandemic, forcing them to seek support. "*We think we're getting the questions that before, peers would answer, or students would ask their lecturers face-to-face at the end of the lecture. Whereas now, they don't have those opportunities and so yeah, I think they're coming to us*".

However, for the majority, engagement was still down overall, with numbers "*nothing compared to what we were getting*". One participant stated their drop-in support although busier than in the early stages of the pandemic was still 50 students down a day compared to before the pandemic, with another estimating that engagement was 20-30% lower overall.

<u>Have you found a difference in engagement of different student groups?</u>

This question was intended to be open, exploring potential differences in student groups defined by discipline, year of study, gender, or ethnicity for example. However, it was an area not a lot of practitioners had looked in to, or differences in student groups were not obvious.

Two practitioners had found engagement of engineering students had significantly reduced, with one stating that numbers had "*fallen off a cliff*". Another also found that engineering and computing students were more likely to sit in sessions "*switched off*" needing to be prompted, compared to their education and business students who communicated well with each other in breakout rooms. In contrast, two practitioners' highest engagers were engineering students, one specifying that these were second year students and the other that they were mostly male. In contradiction to that, although gender was only mentioned a few times, one practitioner explained gender was biased towards females with another saying engagement of young white males was lacking, possibly due to the support team being only one ethnic demographic.

In terms or year of study there wasn't a trend in engagement, with practitioners having mixed experiences. For some, first years and second years had low engagement, for others third years and above were less likely to use the service. One stated that first year students had not experienced what support was like in-person and so did not know any different and therefore engagement was easier. But in contrast, another practitioner explained that in the preceding weeks of March when the pandemic began, many first-year students at the time did utilise support because they had experienced what it was like before it moved online. These students, now in their second year at the time of the interview, were still the highest engagers. However, when the new 1st year students arrived, they had no prior knowledge of the service, and so engagement was non-comparable. For third year statistics support, one practitioner had not seen a change, but for another, final years stopped using the drop-in service and really utilised the online study groups that were put in place. Finally, one participant also stated that Masters students had also stopped accessing support.

Other remaining comments related to more personal qualities of the students. One practitioner felt that the students she was seeing at the time the interview took place were more open about their feelings with another thinking they were seeing an increase in mental health issues.

<u>In your opinion what do you think will make students engage with online MSS more?</u>

The most common answer to this question was practitioners wishing that they knew, "*I've thought, thought and thought, and I just don't know*", "*I'm not sure we ever knew what made them engage face-to-face*". However, a few different suggestions were made, and most commonly were about improving advertising, and getting students to know about the service in the first place, "*...just knowing, like I think you can't engage with something if you don't know about it*".

Testimonials, from staff and students alike, were suggested by five of the practitioners (41.7%). As one practitioner explained, students need to hear good examples of online learning and support, as "*bad experiences are preventing them from accessing support because they've been burnt before*". They gave examples such as lecturers just leaving students to learn from lecture notes. Hearing positive recommendations from peers can make the service seem more approachable. As with staff testimonials, it is an opportunity to give students a familiar name to go to.

Targeted advertising was also suggested by three practitioners (25%), including learning from past interactions and engagement data to help. Non-engaging groups should be discovered and then targeted, and when advertising services carefully select those that are the most applicable. "*We've previously taken more of a, not a scattered approach, but more of a 'here are all of our services', rather than saying, 'actually think about using us for this'. So be a bit more targeted*". Targeting suggestions also included advertising at key points during the year.

Final advertising ideas linked to improving and displaying support services as being as accessible as possible. One practitioner (8.3%) explained that "*for me, I really like to prepare when I'm* [about to try something new], *or visualize, or think about what I'm about to do, that I feel comfortable about it...I think there must be students out there that aren't booking appointments but need them because they just don't know quite what it's going to be like*". They therefore suggested making videos to explain just how to access support.

The first of the remaining ideas for encouraging students to engage was building relationships and community. This requires improving communication between the support services and other areas of the university, such as academic staff and the student union, with the goal of promoting support services with these channels. But also, building relationships with the students. One practitioner explained that she often had the same students coming back to seek support from her, including one student who sought her out specifically for his entire degree. This suggests students feel comfortable with a familiar face and therefore are more likely to access support again.

The final suggestions of improvements were practitioners being more proactive in reaching out to students, seeking out and implementing improvements, and learning the most effective ways to support online. "*I think online teaching all together can be very good, but it has to be taught*".

Overall, the majority of suggestions linked to getting the word out and making support as easy and approachable as possible, *"If it were as easy as just walking in a door".* As one practitioner put it, "*to ask for help you have to admit that you can't do it and that is a really big thing for anyone to do*" without support being difficult to access on top of that.

However, these are just the opinions of practitioners, and as one practitioner said, "*the way forward is really just to ask the students themselves what would appeal to them*". This approach had already been planned as the next phase of exploration and is reported in Chapter 5.

<u>When pandemic restrictions are lifted and we enter a new normal, would you continue with the online support methods your institution currently uses?</u>

All but one practitioner said they were going to offer some form of online support when pandemic restrictions were lifted. The final practitioner expressed that they would like to, however they expected their institution to revert fully to in-person. The flexibility for distance students was frequently mentioned again as reasoning for still wanting online support to remain in some capacity when in-person provision was once again possible. For one practitioner this could *"be seen as a benefit of the pandemic which will last to the future".* The idea of keeping the option open for students to choose how they would like to be supported was desired, to keep that flexibility, but bring back the missing social side.

Some practitioners did have different opinions and experience as to what worked well online and what would be better in-person, but the general consensus was to keep online resources, and offer some form of one-to-one online support for those who required it, for example during evening hours when students had returned home. Again, the difficulty of online group work was brought up, *"the idea of getting students to work on in groups is nowhere near as good online",* where even the practitioner who found some success with them said they may be moved to in-person.

However, two practitioners expressed their concern for managing both online and in-person support once both were possible. One participant explained that if they offered the same number of online hours they were currently, as well as bringing back the in-person support they offered prior to the pandemic, they would be providing double the number of hours. Hence, as one participant worded it, an "*optimal mixture*" of online and in-person support will need to be determined.

<u>What are the biggest drawbacks of online MSS that need fixing? Any ideas about how they might be fixed?</u>

Although this question was similar to question two, it focused specifically on drawbacks of online support, and explored if practitioners had begun to think about potential solutions.

The most common drawback to online MSS that practitioners mentioned here was technological issues, such as internet connectivity; downloading needed software at home without aid if things go wrong; or having the necessary tools in the first place. A particular concern was the difficulty in writing mathematics online. The solution suggested for this was finding a way to supply students with tablets and styluses with the required software already predownloaded. One practitioner suggested a fund could be set up for this means. Another participant spoke about how technology has already advanced since the beginning of the pandemic, and with time, better technology with less problems such as internet connectivity will be developed. Linking to this, and a clear major area of concern during these interview questions, difficulty with encouraging group work in an online setting was brought up again. However, as one practitioner described, this was not only an issue of getting students to talk among themselves in breakout rooms, but also how to present what they should be working on in every room, which could also be a software limitation.

Interaction and "*Communication, communication and communication*" was a close second. Participants repeated the issue of not being able to utilise students' unspoken cues; body language and facial expressions being lost in an online setting due to cameras being off making it a challenge to read the room and gauge if students are involved and understanding. "[In-person] *you can see the whites of the eyes, so you know whether they understand them or not*". As a result, spontaneity in sessions was lost, particularly for questions and answers, a practitioner voiced a concern that there is a risk of becoming faceless. Getting students to turn their cameras on was unsurprisingly a suggested solution however participants did not propose on how they would go about doing this. Therefore, one practitioner suggested constant encouragement throughout the lesson to maintain engagement, and the use of polling as a feedback mechanism to test students' knowledge and understanding would mitigate the loss of visual cues.

A couple of practitioners chose getting students to turn up in the first place as being the largest drawback, because "*if the students don't come it doesn't matter how technically good it* [the support] *is*". This drawback links back to the improvement of advertising. Exploring engagement data prior to and during the pandemic to see which students engaged with what type of support, and then investigating why, was suggested as a place to begin. In relation, another practitioner also said that accessibility needs to be improved, in that joining online support should be just as easy as walking in through a door would be, suggesting a booking system should be removed for a more natural method of accessing the service. Particularly as one practitioner mentioned that online learning can create its own anxiety, and having an easy-to-access service could help mitigate that.

Finally, the last drawback to online MSS mentioned was the need for new pedagogy and having to teach students how to learn in an online setting. However, practitioners believed that more will be learned over time, and if experiences and methods could be shared between practitioners, it will help others to build on this new skill requirement.

<u>What do you think MSS support will look like at your university when there are no pandemic-based restrictions on what you are permitted to do?</u>

This question was asked to explore what MSS may look like in the future in any form, not just online support, in the aim to discover if practitioners had thought about how online and in-person methods might work in conjunction.

All but one participant anticipated a split in provision being offered in-person and online, with some weighting proposals of 60/40 to 80/20 in-person to online. The remaining participant was from a distance institution and revealed that they would probably keep providing provision as if pandemic restrictions were still in place, and their online provision was probably only going to continue to grow.

Some support methods would also be offered in both settings, particularly one-to-ones such as appointments and drop-ins, with many wanting to offer a choice at discipline or student level. This was to particularly cater for evening hours and distance students, to "*offer the sort of experience for a remote student as if they're in the room*". Other provisions would be held either online or in-person. For some workshops and tutorials would be kept online, where they could be recorded and uploaded as video resources. Online resources already made would be kept online with one practitioner explaining that their in-person resources would be converted as well. For solely in-person, having or bringing back a physical space was also important to a few, with one expressing the importance of *"inviting students to the support centre to introduce the student tutors, introduce the function, what's offered by the support centre"*. Other methods included workshops, study groups and embedded sessions all in-person. When practitioners discussed returning to in-person delivery, the phrase "*bring back*" was regularly used, implying old support methods would be returning. What was not mentioned was review of that provision, using what was learned over the pandemic to improve or change previously used methods, if necessary, to better co-exist alongside online support.

Some practitioners had thought about how offering both in-person and online simultaneously may work, however. One explained they would have to offer less hours of each type in order to accommodate providing support in both settings. Another suggested having onsite computers set up to deliver remote support from the in-person centre. The idea of using the technology purchased to help with online support to aid in-person support, namely the tablets and styluses where notes could be taken during a session and then sent over digitally to the student, was also discussed.

In general, despite the benefit of offering some one-to-one support online for distance students, there was a general consensus that in-person support would be the major form of provision: *"everyone seems to be agreeing at the minute that face to face is the way forward"*. In-person support methods were desired to overcome the issues of online support that had been brought up across the interviews (for instance, loss of unspoken cues, technological issues and writing mathematical notation in an online setting). Interaction, communication, and community were recurring missing elements of online support provision, as one practitioner stated, *"you miss seeing students because that's why we got into it in the first place"*.

4.4.2.1   *Underlying interview themes*

After completing the inductive analysis on the 12 interview transcripts, and refining and developing emerging ideas, eight thematic groups were identified. Table 4.3 shows the frequency of how many times each theme was mentioned as well as how many of the participants mentioned it. Each theme will be discussed in detail below.

Theme	Frequency of mentions	Proportion of participants
Reduced interaction	45	12/12
Flexibility	35	12/12
Technology	35	10/12
Advertising concerns	29	10/12
Effort	15	9/12
Time	24	8/12
Anxiety	20	8/12
Training and Knowledge	18	8/12

Table 4.3 The frequency of mentions of each underlying themes identified in the January and February 2021 interviews, and how many practitioners stated each

These themes are discussion-generated, as explained in Section 4.3.2 they were produced as a result of repeatedly reading the text rather than arising just as a result of a dedicated question. Note that the 'advertising concerns' theme has overlapped with the topic of question four of the interview, however. The reasons as to why it was still included as a discussion-generated theme are given under the associated heading.

Reduced interaction

Reduced interaction was the biggest concern shared by the 12 participants, mentioned at least once by all 12, and a total of 45 times. It was also the most mentioned theme by five participants. This category encompasses the barriers to effective interaction that online MSS presents and contains two key points.

Firstly, the most mentioned point was tutors not being able to access visual cues to gauge student understanding, regularly mentioned as a result of technology. Particularly with students either not having cameras or not turning them on, the largest concern was not being able to know if the students were following or not and in particular, not knowing if they were being truthful when claiming they understood. Much unspoken communication is lost when not being able to read facial expressions or body language, "*... not really knowing if the student has actually understood what you're saying; if your ideas are getting across*" and "*... [in face-to-face support] you can see the whites of the eyes, so you know whether they understand them or not ...*".

Secondly, loss of interaction in general was also a great concern, "*... it's that kind of interaction, student-tutor and student-student interaction I think that's difficult to resolve*". Whether the interaction was student-to-student, student-to-tutor, or staff-to-staff, any dynamic involved with MSS was mentioned at least once by the practitioners as being affected by this reduced interaction, with one participant also mentioning the struggles of establishing relationships between remote campuses. Student group work, in particular, was brought up by six participants. These comments ranged from the lost opportunity for groups of students just to use MSS centres as a workspace, to failed attempts at trying to recreate social learning interactions online.

Flexibility

This thematic group was also mentioned at least once by every participant, with 35 mentions in total. All key points made in this group were positive towards online MSS and highlight what practitioners felt was the main benefit of this new way of working.

Accessibility was acknowledged as the foremost benefit, particularly regarding remote campuses, "*... some students will find it more convenient ... because they're um they're part-time students or because they're from remote campuses*". Particularly with online drop-in, interviewees often referred to the ease of students accessing support immediately rather than having to travel to campus, making them more inclined to use it. This links to the ability to offer support for more hours than in-person methods could be offered for, for various reasons such as student schedules and venue availability for institutions without a dedicated physical centre. The availability of more timeslots means online support can be provided at a time that suits the individual student. This was regularly mentioned as another advantage: "*... and the benefit to being online is that we can reach our students when they are available to be reached ... rather than it being a face-to-face thing on a Tuesday evening and if a student has to be taking their child to cubs or whatever ... we can run them during the day, evenings, Saturdays, Sundays.*"

um we can run them at times suitable for our students that are living abroad ... and I think that's the real advantage to online support that you can't have with face-to-face support".

Both these points extend to being more accessible to all types of students, having the opportunity to access support from an external location at a time that suits the student can reach those that could not be reached by in-person MSS. Mature students who commute or have children to care for were regularly referenced as greatly benefiting from the new flexibility. But these benefits also apply to students in general who can still ask questions even after returning home. All these factors apply to regular student life but were especially important when external circumstances due to the pandemic were interfering with academic life, making traveling to campus even more difficult or sometimes impossible. This also links to another advantage, particularly in regard to what institutions were planning moving forward, and that was be able to give the students the choice of online or in-person support. Half the participants stated at least once that their opinions towards online MSS were negative before the pandemic, but they are now recognising the flexibility that offering both online and face-to-face support can provide. "*We can just say 'well if you want it online we'll have it online'*".

Technology

There were slightly mixed opinions of technology, but generally the opinions were negative. Three practitioners mentioned some positives of current technology, mainly praising that what they have works well, but with the caveat that this was probably only for the time being.

Nevertheless, it is evident that most practitioners are finding technology to be troublesome, with nine out of 12 giving at least one example of issues. Most often these related to sharing work and writing mathematics online: "*I'm hoping that software comes along that's better than the stuff we've got just now for writing maths*" and "*students holding up pieces of paper to the camera so that you can try and read their working is not good especially when you're sharing a whiteboard*". Practitioners mentioned that tablets and styluses were a solution, but a lot of students do not have access to that technology, or institutions do not have the funds to provide them. Some students even lacked basic needs for online MSS such as a microphone, "*... some students don't even have microphones. Their microphone doesn't work, and their camera doesn't work and, you know, trying to explain to someone, you know, some kind of classical mechanics problem without them being able to talk to you can be quite difficult indeed*".

It is interesting to note however, some practitioners stated that statistics support is relatively unaffected, or has even benefited from the change to online, as it does not face the same barriers as mathematics support, particularly the pen and paper problem. A participant explained, "*so I only do statistics support, but I find that incredibly useful to have the shared screen and to have you know students working on their own computers they're comfortable with*" and "*I think it was easier for me to adapt with the stats background because so much happens really on the computer anyways*".

As mentioned in the interview summary, other technological issues mentioned were the quality of internet connections, students having to download software at home, and the lack of functionality of breakout rooms. However, as one participant expressed, software companies will be striving to improve the technology currently on offer (to gain a market advantage over their rivals), and so regardless of the current issues, technology will hopefully improve.

<u>Advertising concerns</u>

Although advertising was the subject of the fourth question of the interviews, concerns were regularly mentioned throughout the duration of the entire interview, and within responses to different questions, including for some before the advertising question was even asked. Hence it has been categorized as an overall discussion-generated theme. Within this theme, there are three key areas: word of mouth, footfall, and information overload.

Word of mouth was of the greatest concern, mentioned 15 times by all but two participants. The majority of comments described the importance of word of mouth in their institution's advertising of MSS. Examples such as students telling their peers, lecturers telling their students, or support staff informing non-support staff were given. These practitioners felt that this loss had contributed most to the drop in engagement numbers: "*... we would inform the students and let them know to tell other people that, you know, 'please tell your friends, if there's other people, you can come along and do group sessions'*". Additionally, many expressed the view that getting students to inform their peers was a goal regardless of the pandemic, but it was made harder by the restrictions in place, since the students were having fewer conversations with their peers.

Information overload was the second most frequent concern, particularly with emails to students. Practitioners worried, especially during the induction period, that students were overwhelmed and/or irritated by the amount of information received, and so support centre emails were regularly going unread. "*I'm also like there has probably been cohorts that we've irritated with the amount of trying ... you might actually irritate them to the point that they're like 'oh, them. I can't stand them'...*".

Finally, several participants raised the issue of footfall, that is, students becoming aware of the MSS provision simply by walking past the drop-in centre. There was a consensus of not having previously realized how influential having an accessible in-person site was for drawing students in.

<u>Effort</u>

Effort was an interesting category to consider as it very much seemed to arise as a result of the reflection period after the end of the academic year 2019–2020. Participants have had time to think about their support methods, the strengths, and weaknesses, and why any problems they have come across may be occurring.

Online support requiring additional effort from students and staff alike was a rationale regularly provided by practitioners. Examples of this include "... *it* [online group work] *would involve a lot of learning effort on the students*" and *"... we've* [academic staff] *just got to push that* [communicating to students] *a bit more and get them doing more to push the students through lectures/tutorials announcements"*. Areas requiring more effort were generally related to students actively approaching and using the service, or staff learning how to use new software. One participant claimed more effort is needed from both parties to make online MSS successful, "*many of the disadvantages can be handled by cooperation of students and tutors. So, both of us have to accept the new norm. Both of us have to change their behaviour, change their habits*".

The other main point in this category was motivation, especially the influence of outside commitments due to the pandemic. "*... every student's struggling aren't they, with the pandemic, that they're finding it a lot harder to study*". Practitioners gave reasons for why they thought motivation for engagement had changed. These reasons ranged from students and staff having outside influences which were reducing opportunities for academic engagement (such as childcare, illness and technology issues); to students just simply not wanting to participate with the online learning methods, particularly because of them thinking examinations would be easier due to changes created by the pandemic (online, open book etc.) and so required less work. This is similar to the perception of MSS tutors in Mullen et al. (2022) who felt better prepared students were mostly the ones using online support.

Time

This category had a split opinion. Eight participants in total mentioned a situation related to time, with 24 mentions overall, and it was a key concern for one participant. Four gave examples of the new online situation not allowing enough time to achieve things; three stated that the new online environment has given them more time; and one further participant shared an experience of both sides.

The negatives were unanimous in saying that online methods take up more time. This was rationalised with a range of activities, from the creation process of new methods, to performing the methods themselves. Practitioners explained it left less time for other activities like creating advertisements or planning improvements. "*...what you could do face-to-face probably takes you 25 minutes longer to do online"* and *"we didn't really also have the time to create like proper posters and notifications"*. Four other mentions of time also included current support methods not using time efficiently and ideas on what may be more efficient.

On the other hand, four participants found that moving to online support methods freed up time to achieve more. One suggested benefit was tutors having more time to prepare answers to problems because they are submitted beforehand, "*it can sometimes give the tutors the time to, you know, go and look at, go and look at some information for it*". Additionally, extra time freed up from face-to-face methods meant more time spent on thinking about the future and what is next for MSS, *"... we've got*

essentially all this extra time that we've paid people, that we're paying people for, to be a bit innovative and to try different things".

<u>Anxiety</u>

Anxiety was regularly mentioned in both a positive and negative light. The most common response was that online MSS methods offer a larger form of anonymity, especially as a lot of institutions do not request students to have their cameras on. Therefore, students who are more socially anxious, who would be unlikely to walk into a physical centre for help, feel safer in an online environment.

Embarrassment was a key word in identifying this thematic group; however as one participant picked up on, embarrassment also comes from not wanting your own self to realize you are unable do something. '*I think that's the problem with asking for help at all. It's that to ask for help you have to admit that you can't do it and that is a really big thing for anyone to do*'.

However, online MSS can also create its own anxiety: *"... there's nothing more awful than being at an online event and you know the presentation hasn't started yet so you're looking into everybody's camera and everybody's sitting there like nobody knows if we're having small talk now or not"*. Or, make it harder to deal with: *"face-to-face it's just so much more powerful for getting them to calm down and yeah kind of stop fretting or stop worrying"*. This produces another barrier to overcome.

<u>Training and Knowledge</u>

This final category includes any statement about students and staff, whether they are employed in MSS provision within the institution or outside of it, requiring more knowledge around the provision of online support. This thematic group was mentioned by eight participants, a total of 18 times and was even the main point of interest of one participant.

The majority of the concern went towards the staff as opposed to students, with six participants referencing staff, one referring to students, and one participant expressing a concern for both. A large part of these responses were related to pedagogical practices and staff requiring more training and knowledge in how to best teach online. It was particularly mentioned that students needed to be taught how to adapt their study skills to this new environment to learn effectively. "*... all of us mathematicians and mathematics teachers should deeply think about the pedagogical questions. How to uh make students be active, how to teach students how they should learn, how they should study*".

Additionally, as to be expected, concerns were raised about the requirement of teaching all MSS staff about how to use any of the new technology or software their institution's support centre was now utilizing. "*We don't want to be teaching people about the system as well as providing support in maths and stats*". This links to other themes, with some practitioners stating that having to learn new software requires both time and effort, and as a result is off-putting to staff and students who have already had to deal with all other aspects of university also moving online.

The other main area for concern, involving both staff outside of MSS and students, was simply being knowledgeable of all of what their institution's MSS centre offers. For staff this was in order to either pass on the information to students, *"sometimes we have to, we have to educate staff, quite often admin staff um so that they know that there is, they know the services they're offering"*. In the students' case, this was how to access support themselves, *"And then I suppose the other thing that's a barrier is just knowing, like I think you can't engage with something if you don't know about it"*. This also closely links to the 'advertising concerns' theme.

4.4.3 June 2021

As mentioned in Section 4.3.3, for the purpose of this sampling point the results being discussed here are for the GBI survey only however key comparisons identified between the GBI and German data will be mentioned when appropriate. A more detailed comparison between the two locations can be found in Gilbert et al. (2023). As a different number of respondents completed each question, the number of responses for each has been detailed on the associated figure.
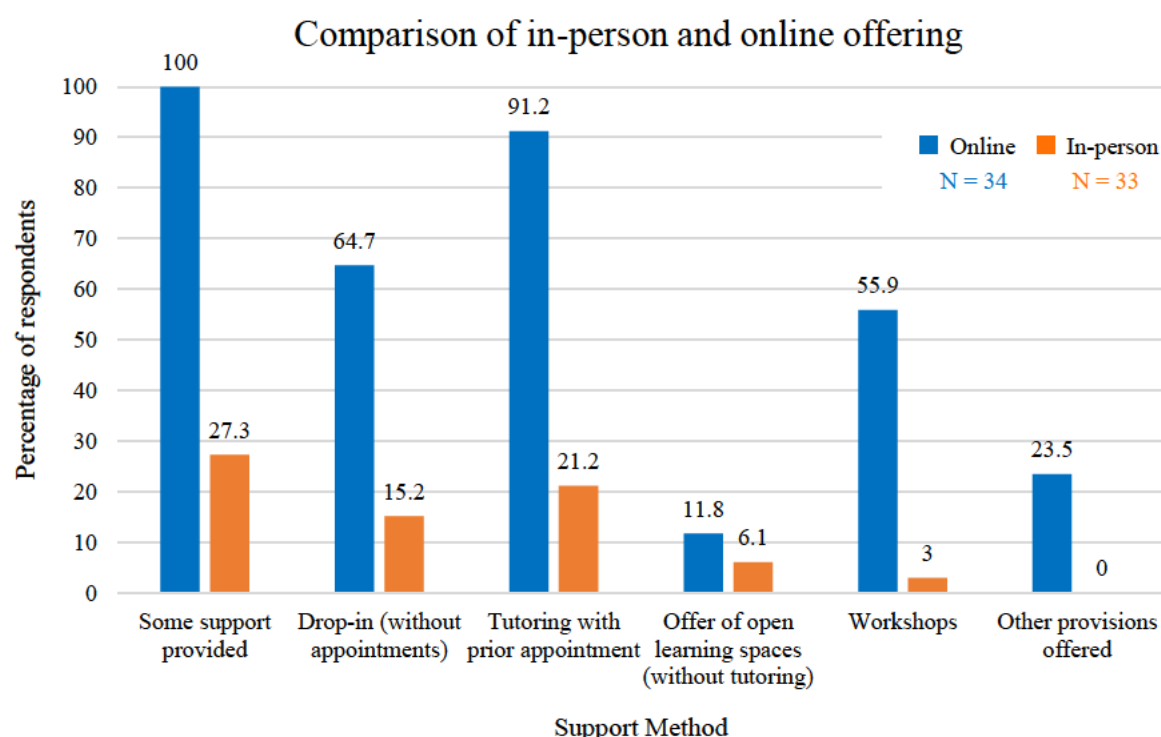
Figure 4.1 *Comparing what online and in-person MSS methods were being offered in the October 2020 - February 2021 period*

To explore how institutions' provision may have changed since the beginning of the pandemic, practitioners were asked what methods of support, both online and in-person, their institutions offered between October 2020 and February 2021. This information could then be compared to what other

practitioners stated they were offering at the second sampling point of this phase, and with what was reported as being offered in Hodds (2020a). This will be discussed in Section 4.5.

Figure 4.1 shows a comparison between online and in-person provision, and unsurprisingly online support methods were offered much more frequently.

The most common service offered in GBI was pre-booked online appointments (91.2%), followed by online drop-in (64.7%). These two provisions were also the most offered in-person. However, an additional option of 'no in-person support available' was provided when asking participants what in-person services they offered, and this was the most frequently given response (72.7%). It was noticed that two respondents did not answer this question. If reasoned that this was because they did not offer any of this type of provision, and combine these to those who did state it, 74.3% of respondents did not offer in-person support provision between October 2020 and February 2021. 'Other provisions offered' included online resources, email support and study group sessions.

In contrast, the least offered provision, for online and in-person combined, was the offer of open learning spaces without tutoring, with only 11.8% and 6.8% of respondents stating they offered this online and in-person respectfully. This leads to a key comparison with the German survey, where online learning spaces was their second most supplied provision (63.8%) next to online drop-in (78.7%), with an additional 32.4% of participants in Germany reporting they made face-to-face learning spaces available to students as well.
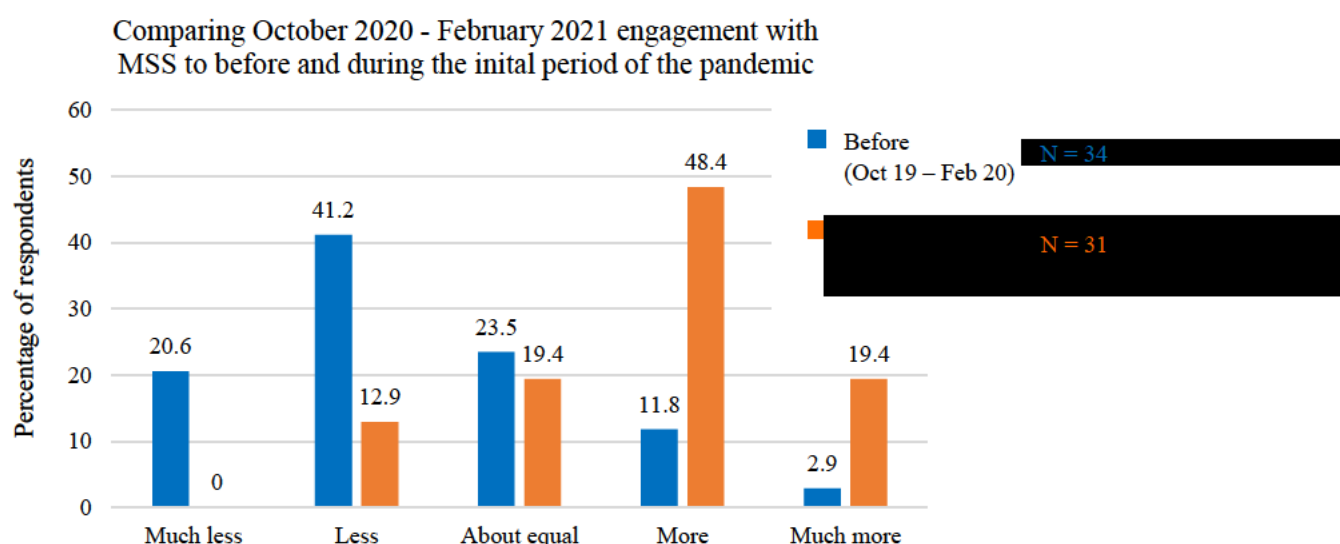
Figure 4.2 *Comparing student engagement with MSS services during October 2020 - February 2021, to before the pandemic (October 2019 – February 2020) and to the initial period of the pandemic (April 2020 - September 2020)*

To begin exploring student engagement, and how this changed over the duration of the global pandemic, practitioners were asked to compare engagement levels during October 2020 to February 2021 to the

same period of time before the pandemic (October 2019 to February 2020), and to the initial period of the pandemic (April 2020 to Sep 2020). The responses are shown in Figure 4.2. Although these periods differ in length, the question was focusing on the general week-by-week level of busy-ness rather than actual engagement numbers.

Overall, over 60% of responses received stated that support was used less or much less during October 2020 – February 2021 when compared to before the pandemic, when face-to-face services were mainly offered. However, practitioners did see an increase in engagement when comparing (then) current levels to during the initial period of the pandemic, with 67.8% of GBI practitioners thinking that support was now being utilized more or much more by students. This pattern was also seen in the Germany data. Three practitioners (from three different institutions) felt that (then) current engagement was about equal to the levels seen both during the initial period and before the pandemic.

In order to explore potential reasons for this observed change in engagement during the pandemic, practitioners' opinions on student preferences were also explored. They were asked their level of agreement on whether two potential influences students face affected their engagement with online support, low self-confidence (Figure 4.3, left), and time-constraints (Figure 4.3, right). Both of these were briefly mentioned in Hodds (2020a), as well as being comparable to the anxiety and time themes identified in the January and February 2021 interviews, hence it was an opportunity to compare if these opinions were still present.
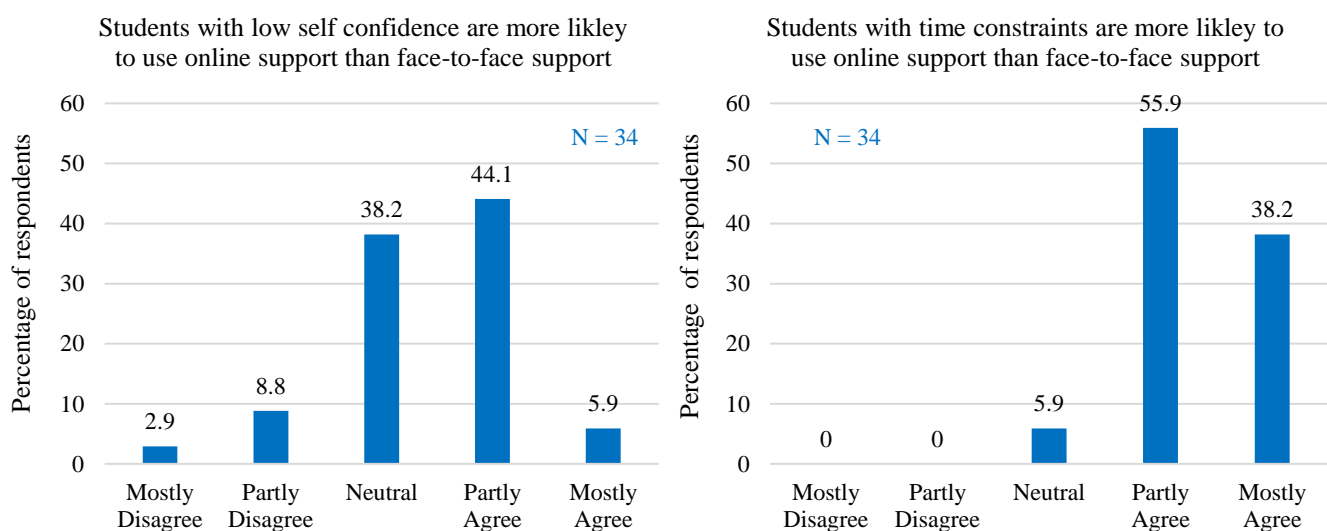
Figure 4.3 *Exploring how far practitioners agree that students with low self-confidence (left) and time constraints (right) utilise online MSS more*

Overall, almost all practitioners agreed that students with time constraints are more likely to use online support than face-to-face provisions, with zero practitioners partly or mostly disagreeing with this statement. Opinion of if students with low self-confidence are more likely to use online support than

face-to-face support was a little more divided. The most common response was partly agreeing (44.1%), but this was closely followed by a neutral opinion (38.2%). 11.7% of practitioners also partly or mostly disagreed that this was the case. Interestingly in comparison, opinion in Germany was a lot more skewed to the left, with 43.2% disagreeing to some extent.

Reduced interaction was reported by practitioners in the previous sample as the largest disadvantage to online support. A particular difficulty faced was the lack of verbal cues making it difficult to determine whether students are engaged and understand the content. The loss of interaction between students was also mentioned, with half the participants bringing up the effect on group work. Hence this was questioned again in this sample, and practitioners' responses are shown in Figure 4.4.
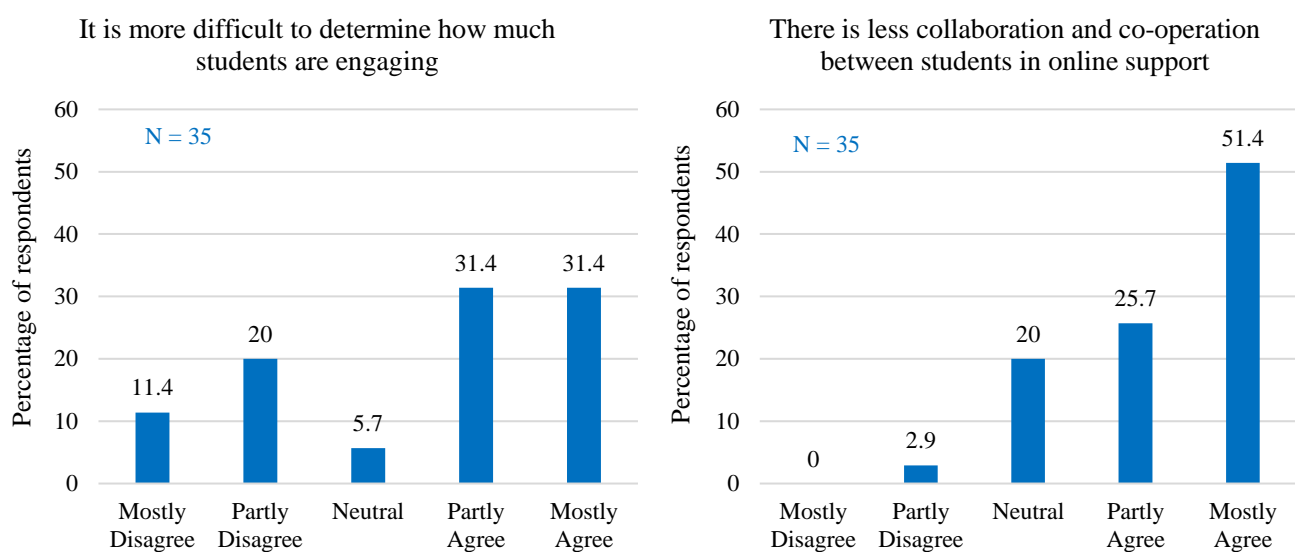
Figure 4.4 Practitioner opinion on elements of reduced interaction caused by online MSS

Although practitioners still agreed overall that it is more difficult to determine how much students are engaging with online MSS, comparatively to the previous sampling point, there was more of a split opinion (Figure 4.4, left). Just under a third of practitioners (31.4%) disagreed to some extent. In contrast, far more practitioners in Germany agreed with this issue, with a net agreement (meaning the combined percentage of those who partly and mostly agreed) of 82.7%. When questioned on student camera usage, only 5.7% of 35 GBI practitioners revealed they felt students always had their cameras turned on. This was regularly brought up in the previous sample as a reason for the loss of unspoken communication and therefore the difficulty in knowing if students were engaged. As the perceived camera usage is still very low, it suggests this split opinion was mostly likely caused by something else.

Figure 4.4 (right) however, shows that practitioners were still in strong agreement with the statement that there is less collaboration between students in online support, with a net agreement of 77.1%, and 'mostly agree' receiving just over half of all the responses for that question.

Word of Mouth is not as effective as it was before the pandemic

Students recieve so much online information, our advertising is often overlooked
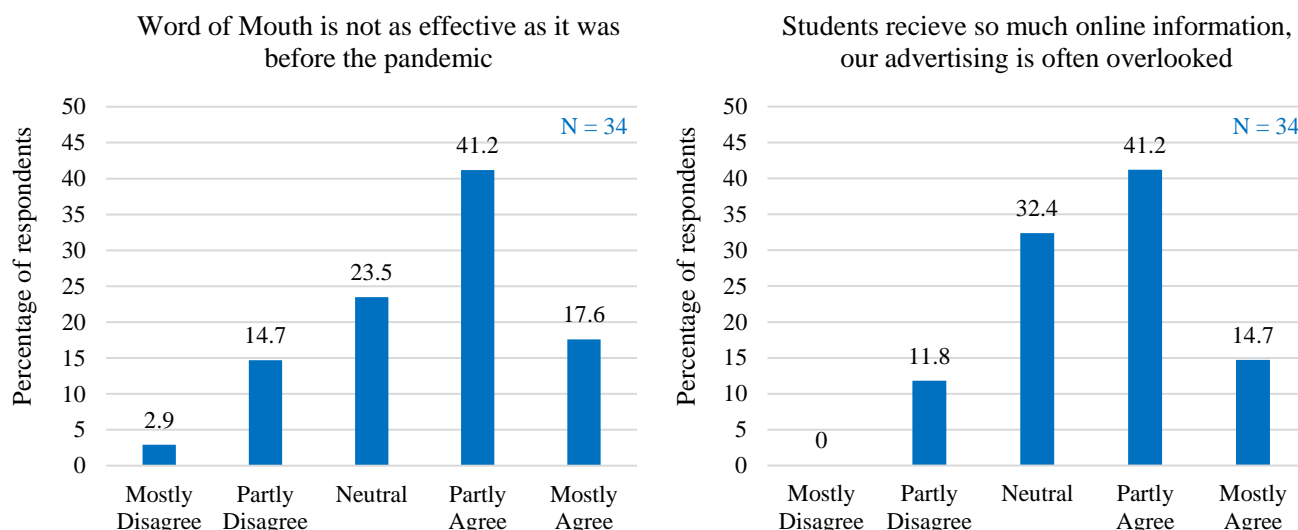
Figure 4.5 *Practitioner opinion of MSS advertising issues*

It is well-known that the pandemic forced all areas of university life (academic and social) online and, during the periods of full lockdown, all information had to be distributed digitally. As discussed in Section 4.4.2.1, concerns with advertising was one of the underlying themes of the January and February 2021 interviews, and two subgroups of that category was loss of word of mouth and information overload. Hodds (2020a) also identified these as two major concerns of advertising issues.

Over half of the practitioners (58.8% of 34 responses) either partly or mostly agreed that word of mouth is not as effective as before the pandemic. A similar result was also found when asked if advertising was often overlooked due to email overload, and partly agree was again the most common response with a 55.9% net agreement. This outcome suggests traditional advertising of MSS may not be as effective in an online setting. However, it is important to consider that this opinion may have been influenced by effects of the pandemic. The majority, if not all, of university communication had to move to email, increasing the chance of overload and MSS advertising emails being buried. Also, verbal communication between people was significantly hindered due to pandemic restrictions in place.

Another underlying theme of the interviews conducted at the second sampling point was 'effort', and in particular, students needing to put more in to actively approach and use the service, and staff having to learn how to use new software to provide support. The latter also closely linked to the knowledge and training theme, where the majority of practitioners who mentioned it suggested that staff needed more training on how to effectively teach online. Hence four months later, it was interesting to see if these opinions still remained.
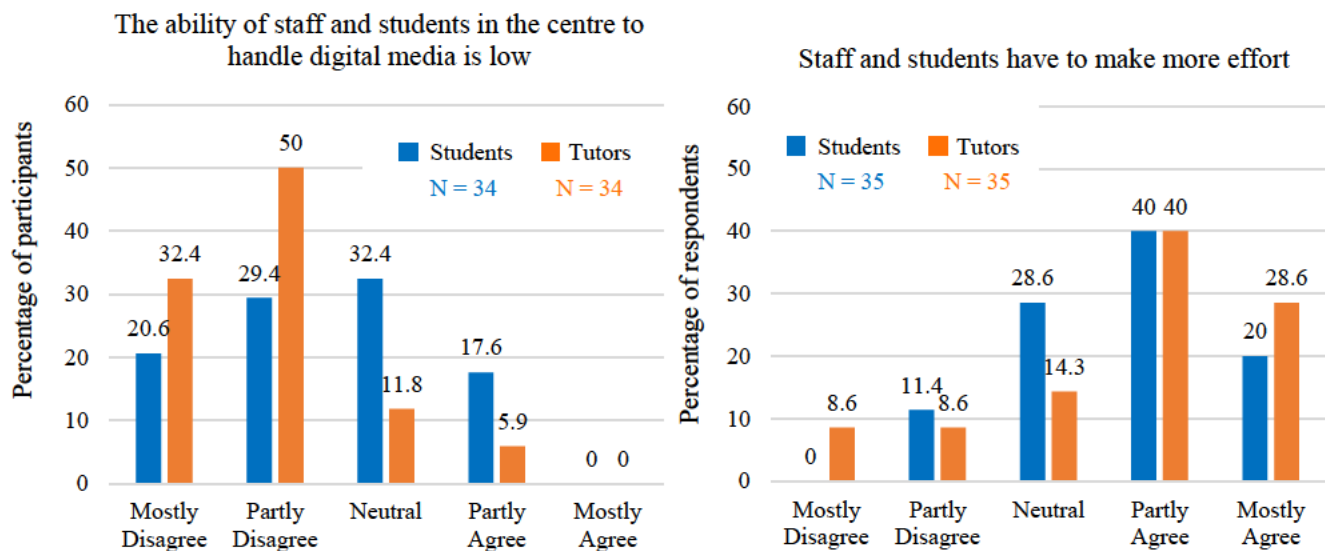
Figure 4.6 *Practitioners' opinion on the ability and effort required for online MSS*

The left side of Figure 4.6 shows the response from practitioners when asked how far they agreed that the ability of both tutors and students (in the context of MSS, not in general) to handle digital media was low. This was to explore if practitioners felt the need for training was still present. The response about tutors' ability was heavily skewed to the left, with a net disagreement of 82.4%, meaning practitioners felt strongly that staff had an ability to learn and use digital media. However, the modal answer was only 'partly disagree', receiving half the responses, and 17.7% of responses were neutral or partly in agreement, suggesting there was still some need for additional training at this point. The opinion on students' ability was less certain, however. The net disagreement was still 32.4 percentage points greater than the net agreement (50% disagree to 17.6% agree), but neutral was the modal answer with just under a third or responses (32.4%).

Looking at the right side of Figure 4.6 however clearly shows that practitioners still feel strongly that more effort is required from both staff and students alike. 60% and 68.6% of practitioners agreed to some extent that staff and students respectively needed to put in more effort, staff to provide online provision and students to utilise it.

At the end of the survey, three open questions were asked to practitioners, the first of which explored how practitioner opinions had changed over the space of the year. Table 4.4 shows the percentage of total responses that fell into each one of three groups: positive, negative or zero change. It is important to note however that the percentages do not add up to 100% because the question also received answers that did not discuss a change in opinion, rather just positive or negative comments regarding online support, and have therefore not been included in the analysis.

Group	%
Positive change in opinion for online support – their opinion has changed to become more positive	65.5
Negative change in opinion for online support – their opinion has become worse	0
No change in opinion – they feel the same now as they did before the pandemic (positive or negative)	20.7

Table 4.4 How practitioners' opinions of online support have changed since the beginning of the pandemic

The most common response was that practitioners were now more positive than they were prior to the pandemic, receiving 65.5% of 29 responses. Responses contained phrases such as '*gained a greater understanding*' and '*more in favour of online support now*'. 20.7% stated that their opinion of online support had not changed, half of which were practitioners who stated they had supported or were preparing to support students online prior to the pandemic. Encouragingly, zero practitioners stated their opinion of online support had become worse.

The remaining two open questions asked practitioners for any advantages or disadvantages to online support that had not been previously mentioned in the survey, and responses were grouped into common ideas which can be seen in Table 4.5 below.

Advantages	%	Disadvantages	%
Flexibility and accessibility	48.0	Interaction and collaboration challenges	47.4
Time saving	24.0	Time consuming	21.1
Convenience	20.0	Engagement and Proactiveness	21.1
Anonymity and intimacy	16.0	Difficulty of online support	15.8
Other (3)	12.0	Other (4)	21.1

Table 4.5 Practitioners' opinions on the advantages and disadvantages of online MSS

The percentages in the table above show many responses mentioned a specific advantage or disadvantage, receiving 25 and 19 responses respectively. Some responses fell into more than one group as some practitioners discussed multiple points, hence the percentages do not add up to 100.

'Flexibility and accessibility' was the most mentioned advantage receiving 48% of mentions. Not having to travel was still highly valued as benefiting staff and students, the consensus was still that

cutting out travel allows for online support to be offered at more times. However, it is interesting to see that this proportion is reasonably less than the practitioners in Germany who brought it up in 72.2% of 33 responses, and the 100% of practitioners who mentioned it in their interview at the second sampling point.

The second most identified benefit was online support saving time, mentioned by 24% of practitioners, with particular reference to when students miss sessions. Without a physical location to commute to, travelling time is no longer required and if the student does not arrive, the tutor is no longer forced to sit in a room waiting to result in a wasted journey. However, there was still a split opinion around this topic, as seen at the previous sampling point. Comparatively, and also the second most mentioned disadvantage, 21.1% of practitioners mentioned that online support was more time consuming. Reasons in support of this were having to allow more time for technological problems, such as internet quality creating a delay, and the inexperienced use of new software causing teething problems. The transition to online also introduced additional considerations that were not required before, for example closed caption editing of video recordings.

Convenience was stated as an advantage by 20% of the practitioners, namely the sharing of digital content such as presentations and collaborative notes made during a session, all of which can be stored in one location for easier access. In addition, 16% mentioned online support having more anonymity and intimacy as a benefit because of the quieter, less distracting environment online support creates.

Finally, there were other benefits mentioned by a single practitioner, and these were: the ability for tutors to save face by checking their knowledge without the student's awareness; students coming to online support more prepared and focused than when in-person; and online support presenting a better environment for nurturing ideas.

For the disadvantages of online MSS, difficulties with interaction was again identified most frequently by practitioners, with 47.4% of responses. Group work and the challenge of collaboration and interaction between students was again particularly mentioned in responses, as well as the lack of social interaction and informality that comes with face-to-face interaction.

The difficulty of online support as a disadvantage was mentioned in 15.8% of responses, with the majority of reasons given relating to the challenge of recreating elements of in-person support in an online setting. The difficulty of gaining an idea of how successful their support provisions are was also brought up.

Further, 21.1% of responses stated that student engagement was reduced, and students needed a higher level of proactiveness to access online support. While pandemic restrictions were in place, they could no longer just see a physical centre and spontaneously choose to walk in. Students had to actively decide they needed additional support and then know where and how to access it or make the effort to acquire

that information. It was also mentioned that it is easier for students to not engage when using support, for example, not asking questions. This is reflective of the 'effort' theme at the previous sampling point.

Finally, other disadvantages that were suggested by single practitioners were: the challenge of maintaining both online support alongside face-to-face provision; the low ability of students to discern quality of resources resulting in practitioners having to supply more; preferring face-to-face support; and technological issues.

Practitioners' plans once a return to face-to-face operation is possible

N = 35

100
90
80
70
60
50
40
30
20
10
0

0 — Return to a fully face-to-face service
94.3 — Offer online tutoring, alongside face-to-face provision
2.9 — Offer online support only
2.9 — Other

Percentage of respondents
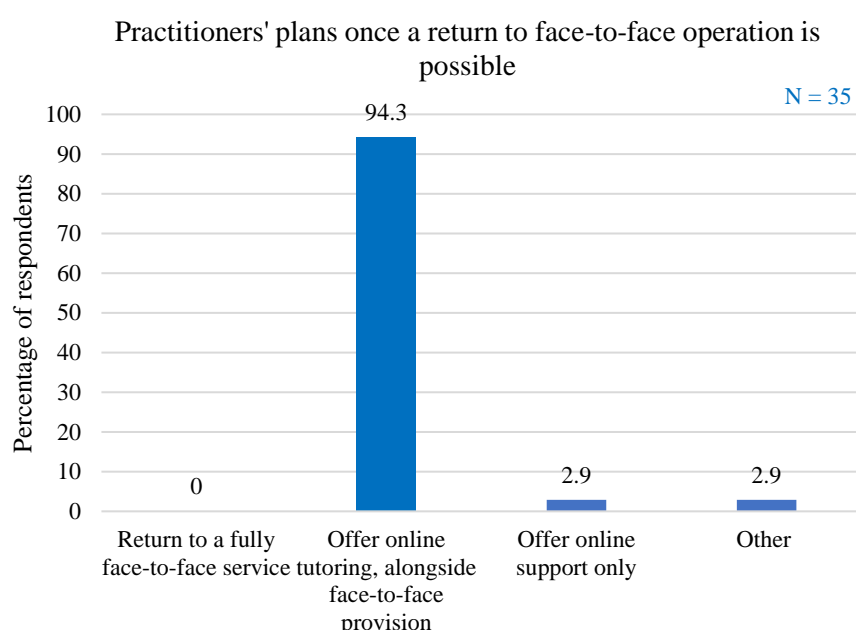
Figure 4.7 *Practitioners' plans for the future of MSS once in-person provision is possible again*

At the time this survey took place, institutions had experienced a year of online support provision, including periods of reflection to consider the future of MSS. Hence practitioners were questioned on their plans going forward once restrictions were lifted and a return to in-person provision was possible.

Practitioners were almost unanimous is maintaining some form of online support alongside in-person provision, with 94.3% of responses indicating this, and an additional 2.9% intending to continue with online support only. The final participant (2.9%) stated 'other' and explained this meant that a decision had not yet been made. No practitioner was planning a return to a solely face-to-face approach.

4.5   Discussion

This first phase of this PhD study aimed to explore what mathematics and/or statistics support methods institutions in the UK and the rest of the world offered during the pandemic, and how that had changed from what they were offering prior.

As reported in Chapter 2 of this thesis and supported by levels of online support reported in Hodds (2020a), prior to the pandemic, limited online MSS was offered by institutions around the world. When

the pandemic hit this significantly increased to 94% of UK institutions in May 2020, and 100% of institutions in both January / February 2021 and June 2021. A pattern was seen, aside from Irish and ROW institutions in May 2020 who provided the opposite, that online appointments were offered more than online drop-in. This may have been due to technological limitations such as the software being used not having a breakout room feature suitable for that nature. Running an online drop-in may have also been more unfamiliar territory then just hosting one-to-one meetings at a scheduled time over conferencing software, and as discovered in the May 2020 sampling point, many tutors wanted to stick with what they knew. This might be a result of a point made in the Jan/Feb interviews by a participant, that making improvements to MSS was less of a priority of the institution than other affected areas of the university infrastructure. When institutions were forced online, the main priority was to get mainstream teaching online, which meant staff giving traditional lectures or seminars, a significantly higher number than support staff, were the focus of development. This left limited time / consideration / resources for any different needs of MSS, leaving MSS practitioners having to make those considerations themselves. Therefore, going with what they knew may have been the most practical time efficient method at the time. This addresses RQ1.

Addressing RQ2, practitioner opinions of online MSS provision were explored; what they were at the start of the pandemic and how they changed as the pandemic progressed.

In May 2020 the most common occurrence was that practitioners were unsure about how to approach MSS going forward. This uncertainty was also present in the themes that arose due to the nature of a discussion question, in particular trying things out and being open to new approaches, both of which practitioners expressed that they were unaware of their next steps. At that early stage of the pandemic, with widespread provision of online MSS having been in place for only two months, this uncertainty was probably to be expected. There still some uncertainty at the second sampling point, January/February 2021, reflected when asked if there were any other online support method practitioners would like to offer, or how to increase students' engagement with MSS. This was just under a year since provision initially moved online; it is assumed most practitioners had had some time to reflect and make any adjustments to provision. Uncertainty was not as obvious by June 2021, practitioners seemed more confident in what they were offering. However, it could be argued that uncertainty appeared in other areas now that practitioners had had more time to think about the future of online support. It can potentially be seen by the more split opinion in it being harder to judge whether students are engaged in an online setting, that was felt more strongly about in the past.

The identification of advertising concerns in the January and February 2021 interviews aligns with the findings of Johns and Mills (2021) who also identified issues concerning advertising of online MSS in their April 2020 survey of American MSS practitioners. Practitioners reported they wanted to improve

their advertising to help increase student usage of support, so the authors recommended that advertising needs to adapt in new and creative ways past the traditional in-person advertising prior to the pandemic.

An interesting finding in the Hodds (2020a) report was that many practitioners stated that although mathematics support numbers had decreased, those for statistics support had stayed the same or had even increased. Although it was reasoned that this was due to the time of year, it was also speculated that students may like online statistics support because it is easier to share screens and use software that can be worked on simultaneously rather than being crowded around one screen in-person. Statistics support is also less hindered by the issue of mathematical notation online. Statistics support not being as affected by the transition to online support was also mentioned in the January and February 2021 interviews, with some even suggesting that it benefited from it.

As stated in Section 4.4.3, a key distinguishing point between the GBI survey and the German survey was the provision of online learning spaces. This was the second most offered provision for Germany, but when combining online and in-person provision, the least offered service in GBI. This phenomenon was also mentioned in the January / February interview themes, when practitioners, none of whom were from Germany, talked about their failed attempts at trying to recreate social learning interactions online. *"Students in groups working at a white board on a set of problems and trying to replicate that in zoom in breakout rooms has been not very successful"*. Even the one practitioner who had found some success in online study groups revealed that engagement dropped off when students realised they were required to work. It creates the question of why online learning spaces were so successful in Germany but have not had the same success elsewhere.

Discussing this phenomenon with the team in Germany, one potential reason hypothesized was the different culture of support in the two locations. MSS in Germany is less formal than that in GBI. Prior to the pandemic it was mainly a physical space for students to drop in and work and get help if needed, where pre-booked appointments were very limited. German students did not want to access office hours or book appointments for fear of more definitively admitting they did not understand something. Similarly to practitioners in the UK, the approach practitioners took to moving support online was recreating what they had in-person as best they could in the new online setting. Zoom or Discord were the most common methods, where Zoom was offered more by staff, and the use of Discord came about from the students. Students also often had their own rooms they ran alongside. Hence students had had experience of this collaborative setting of support, and if they wanted to continue using this service, this was their main option. Additionally, Discord is a voice, video, and text communication service primarily used by the gaming community. Anecdotally, students in the UK do not like academic staff in their social spaces and therefore are less on board with using a platform like Discord for academic support. Students' opinion of group work in general may differ between the locations as well. If students in

Germany value group work more highly than those in GBI, it stands to reason that they would be more active in online collaborative working spaces. This would need to be further explored.

After discussing some areas of interest from the three sampling points, it is important to look at the longitudinal exploration overall. The clearest change across the three data sets is that negativity and uncertainty regarding online support has changed to positivity. In Hodds (2020a), only 72% of practitioners stated that they would continue with some online support after the pandemic. This changed to 100% at both the second and third sampling points. When asked in the June 2021 survey how their attitude to online support had changed over the year, many respondents explained how hesitancy and even negativity towards online support before the pandemic, had been replaced by acceptance and positivity. The phrase '*in-person is better*' became much less frequent. This was foreshadowed in a case study in 2015 by Karal et al. Two mathematics instructors, with no prior experience of distance teaching, taught their course using Adobe connect and a digital pen, and were observed and then interviewed. The authors stated that the instructors' negative attitude towards teaching mathematics online changed as their experience of using the pen-based technology overcame their biases and resulted in them feeling as comfortable as they did teaching in-person (Karal et al., 2015).

'Flexibility and accessibility' was most frequently identified by practitioners as the most beneficial aspect to online MSS. It was the most frequently mentioned positive of online support in the Hodds (2020a) survey, appeared in the May 2020 open questions answers, the second most mentioned theme in the January / February 2021 sampling point, and the highest mentioned advantage in the June sampling point. However, in the June 2021 survey, when compared to the previous dataset, they were mentioned noticeably less. As the advantages of support being flexible and more accessible are well reported (as examples, see Bennett & Lockyer, 2004; Jaggers, 2014; Johns & Mills, 2021), it suggests that other benefits are potentially being recognized more as flexibility and accessibility are now just 'expected' properties online support has. Less time wasted, and convenience were the next two most mentioned benefits to online MSS in June 2021.

The hurdles that educators have faced with students not having their cameras on while learning in an online setting have been well documented (as examples, see Dennen et al., 2007; Roberts et al., 2020; Castelli & Sarvary, 2021). Unspoken communication can no longer be utilised to try and gauge student understanding. However, in June 2021, there was more of a split opinion. In the second sampling point, practitioners regularly brought up students' lack of camera use as reasoning behind the loss of unspoken communication, and hence practitioners were asked their opinion on student camera usage at the third sampling point. As only 5.7% of practitioners felt that students always had their cameras turned on, this shows that perceived camera usage had little to no improvement, and therefore, something else has potentially caused this divide in opinion. One explanation may be that over the year, practitioners have found ways to overcome this barrier, using other methods to gauge students' understanding

successfully, therefore the lack of unspoken communication has become less of a concern. Or there may be other disadvantages that are becoming more prominent. The next two disadvantages of highest concern in June 2021, were online support being time consuming (17.6%), and needing a higher level of proactiveness from students to access services (11.8%), which were both concerns previously stated by practitioners during the January/February interviews. Further exploration would be needed to verify this.

Student numbers at each sampling point still remained lower than before the pandemic, however engagement levels did appear to be increasing. In both the second and third sampling point of this exploration, practitioners stated they had seen an increase compared to when support first moved online. However, as methods being offered have remained relatively the same over the 13-month exploration, with online prebooked appointments, drop-ins, and workshops remaining the most offered provisions in each data set, further exploration is needed into why student numbers are now increasing. As mentioned by some of the practitioners, it may be that students have also become more accustomed to online learning generally, which led to this increased engagement with online MSS. Of course, there may also be other influences contributing to the growing numbers, and therefore the student perspective was investigated in the next chapter.

It was hypothesised at the end of the Chapter 2 that the negative opinions and drawbacks identified by practitioners could have potentially been a result of a method not being an exact re-creation of when it was in-person as well as heavily influenced by all the negative connotations of the global pandemic. Considering the key findings of this phase of study, how opinion of online support vastly improved, it suggests this may be the case. There was also some shift in the importance of some advantages and disadvantages to practitioners, suggesting more consideration has been made. However, support methods have not drastically changed since provision moved online, rather effort goes in to improving these current methods, or converting other in-person provision into online delivery. Hence it seems practitioners are still in the mindset of recreating what they did in-person online, and this may be why the same disadvantages are still being reported.

4.5.1 Limitations

It is important to address any limitations discovered during this longitudinal study and discuss how their impact could be minimised.

The sample at all three points in the practitioner exploration phase was limited to practitioners that had chosen to register with the **sigma** Network Jiscmail list. This creates potential coverage error, the difference between a sampling frame and the targeted population (Alvarez & VanBeselaere, 2005), when generalising the results to all mathematics and statistics support practitioners, as they may not all

be registered. Therefore, the findings of the study may only be applicable to MSS practitioners who are associated with the **sigma** Network.

The general inductive analysis that was conducted on the January and February 2021 and June 2021 data sets was only conducted by a single researcher. Therefore, due to the subjectivity of the analysis, it could have been skewed by bias and influenced by the findings at the first sampling point, decreasing the trustworthiness of the derived themes at these two points. However, as many similarities were identified between the three sampling points, the derived themes are likely to be valid.

4.6   Summary

This chapter details a longitudinal exploration, through the analysis of data sets collected at three sampling points, into how MSS provisions, and associated practitioners' opinions have changed over 13 months of pandemic restrictions. The first sample came from consideration of a final open question on a questionnaire conducted in May 2020. The question explored participants' thoughts on how online MSS should be approached, and analysis offers a first look into MSS practitioners' initial opinions about online support methods during the crisis-driven transition. The second dataset consists of interview data from January / February 2021. By this point practitioners should have had opportunity to reflect on their provision to date and implement any changes they felt were necessary. Hence it was deemed opinion would not be as influenced by the sudden unprepared for transition to online provision. A survey conducted in June 2021 provided the final sampling point, giving a look into practitioners' opinions over a year after the UK was first sent into lockdown, and held at a time where many pandemic restrictions were about to be lifted. All three data sets provided opinions from practitioners in institutions both in and outside of the UK.

Overall, practitioners' opinions of online MSS have improved over the space of the year. Being forced into supplying MSS online by the pandemic, helped practitioners overcome their pre-existing biases and general belief that it was not possible to deliver MSS online successfully. Practitioners became more aware of the benefits online support has to offer, rather than focusing on the initial negatives in a time of crisis, and saw that online MSS is not only possible, but it can be delivered to a high standard. As time progressed, offering chances for reflection, uncertainty and negativity decreased and explanations for identified barriers were explored, offering opportunity for improvement. Practitioners have stated that student numbers are now increasing but are still less than before the pandemic, so will require further investigation into the student perspective of online support methods.

5   The student perspective of online Mathematics and Statistics Support

The second phase of this PhD study was focused on exploring student opinions of MSS. A mixed methods approach was used to investigate the opinions of both users and non-users of MSS, at institutions both in and outside of the UK, two years after the initial COVID-19 outbreak.

This chapter first details the approach that was taken, where an explanation is given as to why students were the focus of this phase and revisits the specific research questions that were addressed. Section 5.2 then describes the methodology, namely the purpose, design, and sampling, of a two-part investigation: an initial study at Coventry University, and a second, larger study looking further afield. The data collected from these two studies were then combined and analysed for an overall look at the student perspective. The way this analysis was carried out is described in Section 5.3, and the subsequent findings in Section 5.4. Finally, a discussion of this second phase as a whole, as well as any limitations identified, is offered in Section 5.5, before giving a final summary of the key ideas within this chapter.

5.1   The approach

Since MSS is an optional provision outside of regular degree-structure, where students voluntarily use (or do not use) the service, engagement has been an ongoing issue. Even before the pandemic, students who would significantly benefit from support were not accessing it (stated in Symonds et al., 2008; Patel & Rossiter, 2009; and Matthews et al., 2013, as examples). This issue only increased during the pandemic. Hodds (2020a) reported that institutions saw their total engagement with MSS over the first two months of the pandemic at a similar level to what some institutions would have seen during a week or even a busy weekday before. Student engagement has been seen to increase in the years after the initial outbreak, however it has still not returned to pre-pandemic levels (Gilbert et al., 2021).

There has been some exploration into why students choose not to engage with MSS (see for example, Symonds et al., 2008; O'sullivan et al., 2014). Typically, students gave answers such as: being unaware the service existed, not knowing where or when it was, or not having got around to going. However, some researchers have speculated that these are only 'surface level' answers given in order to avoid divulging the real deeper reason for not accessing support (Symonds, 2009). Recent research into student engagement with MSS confirmed this. Gokhool (2023) found that when students were interviewed (as opposed to when completing a multiple response question in a questionnaire), they gave affective reasons (a reason influenced by emotion such as fear of embarrassment) for their non-engagement.

Hence after exploring the perspective of the providers of MSS, it was important to then explore that of the people it is provided for. Investigating the opinion of both students who have accessed support, and

those who have not, was also an opportunity to identify current barriers to engagement that are present, and work to discover those deeper reasons for non-engagement. Therefore, this phase of the study addresses RQ3, exploring student opinions of MSS provision and its effectiveness since the pandemic, and RQ4, investigating current barriers to students' engagement and ways to reduce them.

Different student groups experienced the various forms of MSS available to them as provision changed over the course pandemic. These student groups would have all been at different points in their education when the pandemic began and therefore each have a unique experience (depicted in Table 5.1). By focusing on student engagement in this second phase, more of these conditions had become available for exploration. It is worth noting that the below matrix is based on UK students and international students may have had a different experience.

Year group in academic year 21/22	Educational Experience				
	Year 12	Year 13	1st Year UGs	2nd Year UGs	3rd Year UGs
1st year UGs	Beginning in-person, shift to online	Online	Online or Blended		
2nd Year UGs	In-person	Beginning in-person, shift to online	Online	Online or Blended	
3rd Year UGs	In-person	In-person	Beginning in-person, shift to online	Online	Online or Blended
			Type of MSS available		

Table 5.1 Year groups in the 2021/22 academic year and the type of education they experienced over the pandemic up to that year

The types of MSS available to each student group once at university reflected what they experienced in their education, shown by the last three columns of Table 5.1. For instance, third years (or above) had the opportunity to experience all types of MSS provision, compared to first years who only entered university when MSS was online or a blend of online and in-person.

To answer RQ4 and identify why some students are still not engaging, it was crucial to gather the student opinions on both in-person and online support provisions, as well as opinions from non-users of MSS and their reasons behind their choice not to engage. Therefore, within the student groups detailed above, four different usage conditions were also explored: students who have used MSS both in-person and online; students who have only used support in-person; students who have only used support online; and students who have never used MSS.

This phase involved two studies, the first project targeting specific student groups at Coventry University, and then a second larger exploration looking at any type of student at universities across the world. A mixed methods design was used, following an explanatory design, with the aim that the qualitative data could deepen the meaning of and further explain the quantitative data collected first. An initial questionnaire was used to gather the quantitative information, such as student characteristics and use of MSS, as well as some qualitative information to gain a basis for the general student opinion. This then informed the discussion points for the follow up focus groups and interviews, to gather detailed, more in-depth data helping to further explain responses collected in the questionnaire. The following section explains these studies in more detail.

5.2 Collecting the data

5.2.1 Coventry University study

Purpose

The first of the two investigations focused on students at Coventry University. It had two purposes: to trial the research design, and to explore a particular phenomenon of student engagement noticed at **sigma**, Coventry University's Mathematics and Statistics Support Centre. Prior to the pandemic, when support was solely in-person, the student group most commonly utilising support were those studying a discipline in the Faculty of Engineering, Environment, and Computing (EEC). This faculty contained four schools of subjects: 'Computing, Mathematics and Data Science', 'Energy, Construction and Environment', 'Future Transport Engineering', and 'Mechanical Engineering'. Students in the Health and Life Sciences faculty (HLS) however, who belonged to one of three schools of disciplines: 'Life Sciences', 'Psychological, Social, and Behavioural Sciences', or 'Nursing, Midwifery and Health', were using MSS comparatively less. Suddenly, and in contrast, once the support began to be provided solely online during the pandemic, HLS students became the most frequent to access support. This produced the question of why this shift in engagement occurred, and hence students studying a discipline in these two faculties were the focus of this study. Starting the questionnaire with a smaller focus also allowed for the trialling of the research design. Preliminary analysis of the answers helped to inform the discussion questions asked in the follow up focus groups for both investigations.

Questionnaire design

The questionnaire, created using Jisc Online surveys, was designed with the main aim of exploring student engagement. It consisted of five participant information questions, including the consent requirement, followed by eight to sixteen questions depending on a student's use of MSS. It then ended with two follow-up questions for additional detail.

The survey was broken into six sections, using logic to direct the participants to the correct set of questions based on their answer to what forms of MSS they had accessed (see Figure 5.1). It was

important to label and annotate the pages of the survey clearly to ensure the participants knew what set of questions they were receiving and could go back and edit their choice if they had made a mistake. For example, students who selected the 'in-person only' option to what type of MSS they had used were first met with the statement:

"*You have been taken to this page as you have accessed* **'in-person only'** *mathematics and statistics support services at Coventry University*".

This ensured the one questionnaire could apply to all students no matter their use of MSS, and students would only receive questions tailored to their experience.
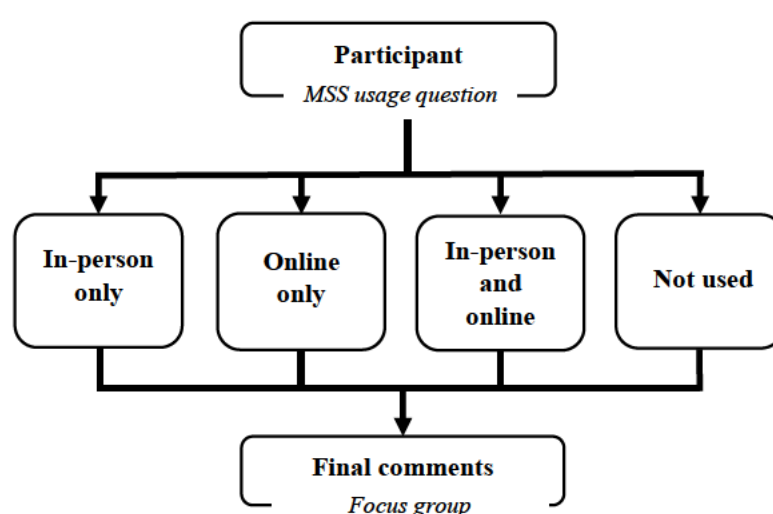
Figure 5.1 Flow chart representing the structure of the student questionnaire

Using different question types in the survey was necessary to generate a variety of both quantitative and qualitative data.

Closed, single choice questions were used to ease students into the survey as well as gather student information for comparison. In the sections where students indicated they had used support, close-ended multiple-choice questions, listing the current MSS provisions at Coventry University at the time, were used. This was to give a general idea about which support methods were currently most popular among students and will help towards answering RQ6 (what could good practice of MSS provision be in our 'new normal'?). Having the options available to choose prevented the participant from having to know or remember all that was on offer and so increased the chance that they remembered every provision they had used, giving more reliable results.

This form of question was also used for the first question to non-users of MSS; as it is easier to select an answer rather than write one, it was hoped participants would be more inclined to answer. However, with this method, there is a danger that participants could be led into selecting an option that is not

really true for them, or selecting one for the ease of it, rather than describe their true reason for non-engagement using the 'other' option. Additionally, as raised in Section 5.1, it has been found that students are intentionally not always honest when supplying reasons for non-engagement, potentially due to fear or embarrassment, which could also decrease validity of results.

The list was made quite extensive however, including some potentially 'deeper' reasons to non-engagement, such as feeling embarrassed or the worry of asking questions they thought were 'too simple'. Also, to combat this, and validate if non-engagers were being honest by comparing to see if similar answers were given, all students who said they had engaged with MSS were asked openly about what they believed were the reasons their peers were not engaging. This was the question: *'Some students who would benefit from mathematics and statistics support are still not accessing the service. Why do you think this may be?'* and was particularly important in the aim to answer RQ4. The idea behind this question was to combat embarrassment by framing it as asking students about other students' perspectives; where they can share something that may also have applied to themselves, without actually admitting so.

Open-ended free-text response questions were used when a detail was required from the participants and listing answers for them to choose was no longer viable. Where participants indicated they only used one type of support, they were questioned on their reason for doing so, what discouraged them from using the type of support they had not accessed, and what could encourage them to engage in the future. As some students would not have had the option to use a certain type of support, it was important that these questions were of this type, so they could state this. Compulsory free-text response questions were also used whenever a participant was asked to explain an answer to a closed multiple-choice question, or when they selected 'other', to encourage them to give as much detail as possible.

There were some shared questions across all sections for comparative purposes. All participants were given scale questions regarding advertising of MSS, as this was a key concern raised by practitioners of MSS in Phase 1 of this PhD study. Using a scale question is particularly beneficial when collecting opinion-based data as they are universally used and easy to understand. A five-point Likert-scale was used, to mirror previous surveys in Phase 1, and to offer participants a neutral option to prevent leading them into an opinion they may not have. Participants were also required to explain their choice via a free text answer, in order to collect additional detail. Finally, all participants were asked whether there were any support methods they would like to see in the future, which also helped towards the final goal of answering RQ6. The last page of the questionnaire allowed students to make any final additional comments as well as ask them if they were willing to participate in a follow up focus group, and if so to supply their student email address (The full generic student questionnaire, applicable to all universities, can be found in Appendix 3. There were only minor changes made from the questionnaire explained here which is explained in Section 5.2.2).

Focus group design

As with interviews in the previous phase, it was chosen for the focus groups to be semi-structured, where a set of main discussion points could be predetermined to give the conversation a direction, allowing for repeatability and therefore comparability between participant answers. However, this approach would still allow participants to speak freely, and the interviewer could follow up on anything deemed necessary, to achieve rich in-depth data. This was also discussed in Section 3.3.2. Hence a protocol was designed to follow when conducting the focus groups; a brief outline of how the session would run, including five questions / topic areas for discussion (see Appendix 4).

The general structure for the running of the focus group was as follows:

Introduction:	The introduction was a key opportunity to reiterate important points in the participant information sheet, such as the reason for the session, the video recording, and the right to withdraw. This was done to ensure all participants were at the same level of understanding before the focus group began. Here introductions were made, and participant numbers were given out and any questions the participants had could be answered.
Icebreakers:	When running a group interview, it is important to make the participants feel relaxed and welcome, at ease to share whatever they want to despite others being around. Hence icebreaker discussions, such as their expectations for and the actual amount of mathematical content on each of their respective courses, were used to get participants familiarised with talking in front of one another.
Warmup Activity:	This was run using a collaborative interactive 'wordcloud' website (https://answergarden.ch), allowing the participants to anonymously share words or phrases linking to a discussion topic simultaneously. This prompted a discussion afterwards, picking out particularly interesting additions, asking participants if they were willing to share what they had written and why. An activity was included at the beginning to get participants engaged and make the session feel more informal than an interview, therefore hopefully sparking more honesty in answers.

Discussion Questions:	This began with asking the participants for a definition of MSS, to ensure all had a clear idea of the topic before progressing. Early responses to the questionnaire were used to inform the design of the remaining questions and topic prompts. Key concerns that arose were the ease of in-person support compared to online, targeted student groups, advertising, and embarrassment. Hence the questions were designed with the aim of gathering more in-depth understanding of the issues revealed in the questionnaire responses and answering any questions that arose from them. All questions were open and additional prompts for each discussion point were created to keep the conversation flowing. The focus group did not have a rigid structure. Participants had the opportunity to listen and respond or build onto answers from their peers, and the researcher could ask additional questions to receive elaboration if needed. Question five's focus, the last point of discussion about students feeling too fearful and embarrassed to attend MSS, was designed to help answer RQ4, bringing concentration back to barriers to engagement, but still framing it in a way that the participants could talk about other students rather than themselves.
Finish:	When rounding up the session it was important to allow the participants to make any final comments as well as remind them for a final time about their right to withdraw and how to achieve that.

The focus group was designed to be able to be run both in-person or online depending on the preference and availability of the participants. When they were contacted, if they provided their consent to take part, they were given the opportunity to provide dates and times that best suited them, as well as their preference of setting.

Sampling

Participants for both the questionnaire and focus groups were gathered via voluntary sampling. The call for the questionnaire was distributed via lecturers within the two faculties. They were directly contacted by email to ask them to advertise the survey to their students via a PDF document containing a brief overview of the study and a link to the survey. Students could then choose to take part if they desired. This was chosen as the best method to reach all types of MSS users.

Recruitment for the follow up focus groups was achieved via two means. The first was through the last question of the survey, where participants were asked to supply their student email address if they were happy to be contacted to participate. Secondly, a mass email advertisement was sent out using a list of students who had used **sigma** services over the past two years. As this second method was used to try

and increase response rate, the email was sent to all types of students over the two years, and not just those from EEC and HLS.

The questionnaire for this smaller initial study was originally only targeted at HLS and EEC students who, at the time of this data collection, were in their second year of studies or higher. This was because at the initial launch of the questionnaire, first year students had only been enrolled for a few weeks which was deemed not long enough to fully experience and develop an opinion of MSS. The running period of the survey was later extended and modified to include first year students to try and boost participation. In total, the questionnaire was open from October 2021 to August 2022 and received 19 responses, 14 from EEC students and five from HLS students.

One focus group was conducted in February 2022 which had four participants. These were three EEC students, studying computer science, mathematics, and motor sport engineering, and one Global Learning PhD candidate, exploring internationalization and Bangladeshi UK domiciled students' engagement with short term mobility. The PhD student was the only response to the mass email recruitment method, so although she was not specifically in EEC or HLS, was still included in the focus group to offer a different perspective from the three EEC students participating. The consensus was to have the focus group online, so it was held over MS teams and the session was recorded purely to generate and review a transcript for analysis, and then deleted. All participants consented to being video recorded.

5.2.2 International study

Purpose

The second investigation in this phase extended the population which it was targeting, from specific Coventry University students to students at other universities outside of Coventry, both inside and outside of the UK. This was to increase the generalisability of results, thereby making any final recommendations at the end of this study applicable to as many institutions that may find them valuable. This was also to mirror the reach of the practitioner exploration in this PhD study. Additionally, it was also an opportunity to gather current information on what MSS services universities around the world were offering at this stage.

Changes in design

As the data from the Coventry University study was also intended to be used in the final data analysis, only minor changes were made to the questions when creating the survey for the larger study so that a strong base for comparison was maintained (see Appendix 3).

Use of language needed to be amended to be applicable to a wider audience, hence anything specifically related to Coventry University needed to be altered. For example:

*What **in-person** services have you accessed while at Coventry University (Choose all that apply)?*

o *Drop-in (i.e., without appointments)*
o *Tutoring with prior appointment*
o *Using the centre as a workspace*
o *Workshops*
o *Other*

In the above question support provision types detailed in the list are specific to Coventry University, hence needed to be removed, as different universities may have offered different support methods. Therefore, the question was adapted from a multiple-choice format to a free-text format, as seen below:

*What **in-person** services have you accessed while at your university (State all that apply)?*

All mentions of Coventry University, or its faculties were removed, using more generalised language in its place, such as '*your university*', as well as language changes corresponding to the new form of the question, e.g., '*choose*' to '*state.*' An additional question was required at the start of the survey asking students for the name of their institution, which would enable responses to be separated so that participating universities could receive a summary of their students' responses.

Very minimal language changes had to be made to the focus group protocol. The most significant difference was adapting to run the focus group protocol as a solo interview or two-person focus group due to response rate, by removing the warmup activity, as this was only able to be run with multiple participants.

Additionally, when contacting other universities to recruit students, which is explained in more detail below, a word document was sent targeting an MSS practitioner at that university. It contained seven questions, including one achieving their consent, regarding the provisions their university offered prior to and during all stages of the pandemic, up to the time of this phase of the study (see Appendix 5). This provided additional context needed for analysing student responses detailing MSS provisions at their institution.

Sampling

The most notable change from the Coventry University investigation was how participants were recruited. It was still via volunteer sampling, but the call for participation now needed to be made through 'gatekeepers' at universities that were willing to participate. This was a mathematics and/or statistics support practitioner, registered on the **sigma** JiscMail list (a self-registered list of MSS practitioners), who would be the source of correspondence for that university. The study was advertised via a mass email using the mailing list, where potential gatekeepers were sent a letter explaining the purpose of the study, a document containing questions about their university's support provision, and a

participant information sheet explaining their role in the study. They were informed that if they agreed to participate, they would receive a copy of their institution's data.

The original PDF document that was used to advertise to Coventry students was upgraded to an advertising poster. The purpose of the upgrade was to make it more visually appealing and encourage engagement. This was sent out once a gatekeeper had returned their answers regarding their provision at their institution. The addition of a QR code as well as the link was so that gatekeepers could distribute the posters both digitally and / or physically, whichever best suited their institution. This was to ensure students could access the survey with ease with limited effort required from the gatekeepers.

Focus group recruitment happened in two ways. The first, rather than supplying their email addresses in the last question of the survey like before, if they wished to register their interest, they were prompted to click on a link that opened a mail application within their browser. This gave them the opportunity to use their student email address to email their expression of interest to a researcher on this study, who did not have access to the questionnaire responses. This eliminated the possibility of matching up the email addresses with the answers and preserved anonymity. The emails were then used to contact students for the focus groups. Additionally, to increase uptake of participants, gatekeepers from institutions that responses were received from were contacted via email later to help gather students for a focus group or interview.

This questionnaire ran from February to August 2022 and produced 128 responses from eight different universities across the world, including one unknown institution, namely England (1), Ireland (5), Scotland (1) and Norway (1). Unfortunately, due to a low response rate for focus groups, mainly individual interviews were conducted for the larger study. The same protocol was followed, with the exclusion of the group warm up activity. Four interviews and one two-person focus group were conducted online using MS Teams or Zoom, in June and July 2022, with six participants from the following courses: Science with Education (Computer Science and Maths); an access course to Science; Agriculture; Medicine and Engineering; a mature student access certificate (Humanities); Engineering; Applied Maths (Theoretical Physics); and Applied Maths (Experimental and Mathematical Physics).

5.3   Data Analysis

As the main aim of this phase of the study was to gain student perspective as a whole, and there were very minor changes made between the two investigations, the data from both the Coventry University study and the international study were combined for the data analysis which is discussed below.

5.3.1   Questionnaire

Across the two questionnaires, there were 147 responses in total. Student characteristic data, namely gender, year of study, discipline, and MSS use, have been summarised and displayed using bar graphs.

The bar graphs offer a visual representation of the percentage of participants belonging to each option inside a demographic characteristic. Chi-squared tests were then used to explore whether those characteristics had an influence on the type of MSS that the students had used. Pearson's chi-squared test of independence can be used when exploring if two categorical variables are related, namely if the probability of belonging to a specific group in one variable is affected by the other. These tests were performed using Excel.

The qualitative data produced from the questionnaire was analysed using a basic form of the general inductive approach as described in Section 3.5, where responses were sorted into groups of common ideas. A percentage of the total number of responses to that question was then calculated and this information was displayed in tables. It is important to state that some answers were given in Norwegian and were translated into English using google translate. Therefore, some meaning may have been lost due to any inaccuracy of the translating software.

5.3.2   Focus groups and Interviews

After reviewing the video recordings and editing the transcripts appropriately, the student focus groups and interviews generated six transcripts ranging from six to 15 pages of text. These were explored in two ways.

Firstly, the key points that participants made for each main discussion question were summarised. As each question was designed with a particular aim, it was important to see what answers were generated as a result and see if there was any comparative or conflicting opinion in each of the areas explored. This was exploring the information received as a direct result of the question, used to support, and further explain the results from the questionnaire.

Secondly, the transcripts were then viewed as a whole, and analysed using the general inductive analysis process as described in Section 3.5. To reiterate, this was the process of repeatedly reading through the text to identify patterns of shared opinions between participants, to group and refine into themes, answering a particular research aim. In this case it was to explore, at the time of data collection, the current student opinion of mathematics and statistics support. This was again performed by hand, as although the method may take longer, it was felt there was more control over the reasoning behind the selection of themes and the choices that were being made.

This analysis was performed as a means to explore any underlying opinions the student participants had; those that arose naturally due to the nature of discussion. It is important to clarify again, as with the analysis of the practitioner interviews, an idea was only considered to be a theme if it was repeated by multiple participants at different times throughout the interview, and not only as a result of a question. This was because when participants were asked a question, they were forced to say something about that topic, rather than bringing it up because they felt they should. Hence, if that was the only occasion

of an idea arising, it cannot be classed as a theme as it was clearly led by the questioning. However, it was again natural for participants to begin discussing ideas that were later questioned about, and hence there was some overlap. The same additional considerations were taken as detailed in Section 4.3.2, and are summarised for convenience below:

- If a participant made a point, diverted to another topic, and then reverted back to the original point, this was considered two separate mentions
- If several ideas were mentioned together but could all be linked under a broader overarching theme, they were classed as separate mentions
- Both the frequency of mentions of a concept and how many practitioners raised that idea were considered when deciding on themes

There was also one additional consideration taken due to having multiple participants being interviewed at once. There were multiple occasions where participants agreed with each other, offering short responses of agreement such as '*yeah*'. These short replies were not classed as mentions of a theme from both individuals. To count, they would have had to repeat what a peer said, and there were cases where this did occur which supports why this decision was made.

An initial list of 12 themes were identified, ranging from being mentioned by all participants to only two. To condense and refine the list, links were established between themes, and these were combined as sub-groups under an umbrella term, leaving a final list of eight.

An independent coder also looked at four of the six interview transcripts and generated their own themes using Nvivo. Overlap was found between the themes identified, and this will be discussed in Section 5.4.2.2.

5.4   Results

5.4.1   Questionnaires

5.4.1.1   *Sample demographic*

The following figures display the demographic characteristics explored of the total 147 participants of the two questionnaires. 42.9% of student respondents belonged to an institution in England, 37.4% from Irish institutions, 12.9% from Norway, 6.1% from Scotland, and 0.7% unknown.
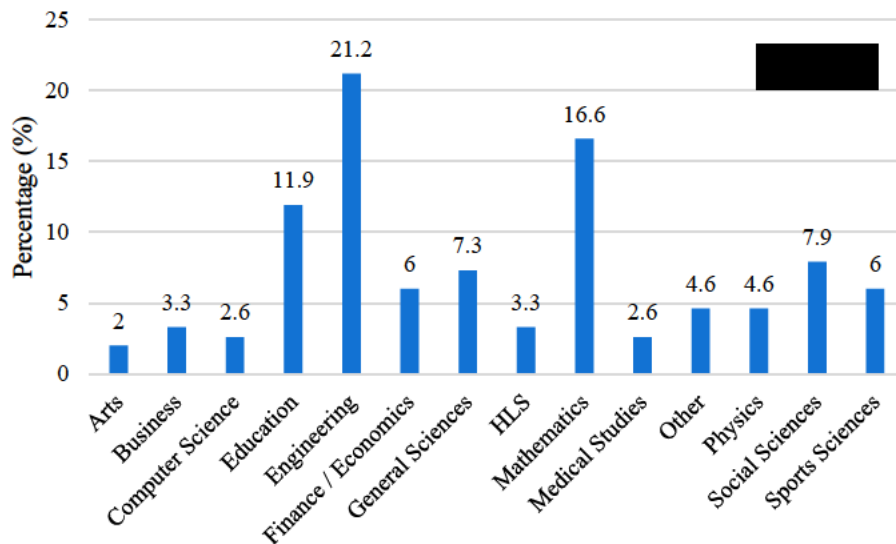
***Figure 5.2** Percentage breakdown of disciplines studied by the respondents to the student questionnaires. Degree subjects can be classed under multiple disciplines.*

As discipline was a non-compulsory free-text response question, there were many different responses and some blank entries. For the purpose of analysis, blank entries were removed, and responses were grouped under an umbrella term which are detailed in Figure 5.2. There were some disciplines that were either dual disciplines, such as 'Physics and Computer Science', or could be placed into two categories, such as 'Sport Psychology'. Therefore, for this summary these entries were duplicated and counted for both, hence why the number of participants is 151 here.

Respondents came from a range of different disciplines, including three from arts subjects who all stated they had used MSS, which is typically rarer. Since the respondents to the survey came from a wide range of institutions in several different countries, it is difficult to imagine precisely what a representative distribution of disciplines would look like. However, it is often the case that students studying an Engineering or Mathematics degree are the most common users of MSS (Grove et al.,2015). These students were the most common type of respondents to reply to the questionnaire. This is to be expected as they are arguably two subjects that contain the most mathematics. It is important to note that as the Coventry University study was only open to two faculties, which could skew the distribution of disciplines, the range of disciplines was also explored for the international study data alone. Mathematics and engineering were still the most common subjects to respond to the survey.
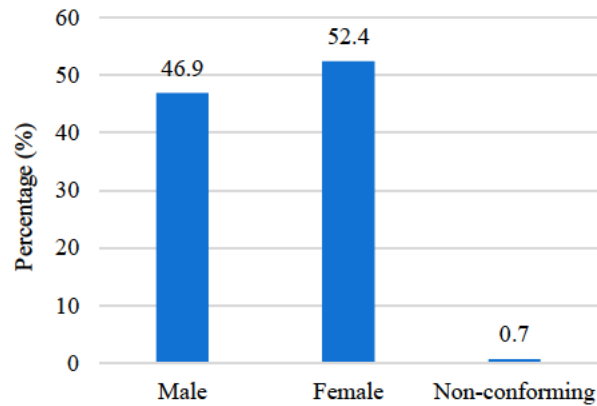
Figure 5.3 *The proportion of the gender of the 147 respondents to the student questionnaires*

Figure 5.3 shows the distribution of gender of the respondents to the survey. There was only one gender non-conforming student to respond, and the rest were relatively evenly split between males and females.
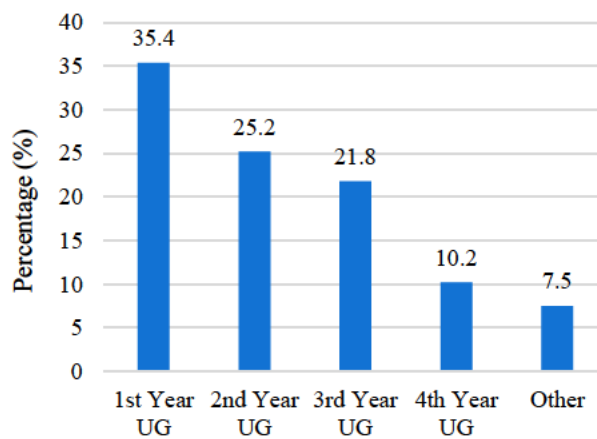
Figure 5.4 *The year group distribution of the 147 respondents to the student questionnaires*

The most common year group to reply to the survey was first year undergraduates, however there is not a huge under-representation from the other year groups. 'Other' included access course (2.7%), foundation year or pre-course (2.7%), placement year (1.4%), and PhD (0.7%).
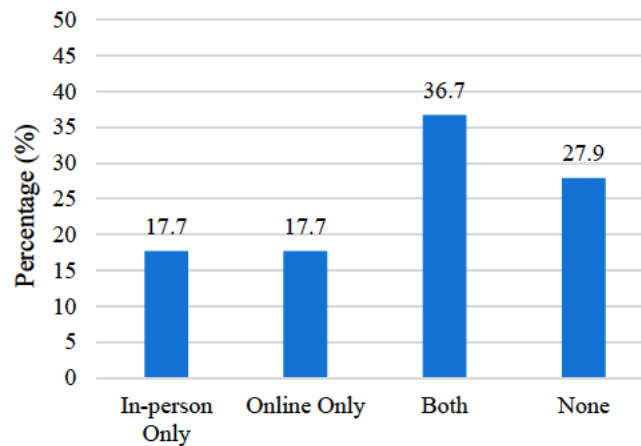
Figure 5.5 *The percentage of the 147 respondents who used each form of MSS*

Finally, respondent usage of MSS was explored. Students who had used both forms of MSS gave the highest percentage of responses (36.7%), followed by those who had used neither type (27.9%). Students who had used just one of the types were equal in number (17.7%). Overall, each type of usage is relatively well represented in this sample.

Chi-squared tests were then used to explore if the above demographic characteristics had had an influence on the type of MSS used by students in this sample. There was no significant association between gender and the type of MSS utilized, x^2 (6, N=147) = 5.1, p = .53, meaning there was no preference to the setting of support based on the gender the students identified as. However, there was a significant association between the year of study, x^2 (12, N=147) = 30.8, p = .0021, and discipline, x^2 (39, N=151) = 70.01, p = .0017 (and still significant when a check was done with the Coventry University data not included), with MSS usage. A significant association between year of study and type of MSS used is to be expected as certain years groups only had certain types of support available to them, as shown in Table 5.1. It is interesting to see however that there was a difference in the type of support used based on the discipline a student studied, and therefore this was explored further.

Education and Mathematics students had notably more students having used both types of support compared to those who had only used one type or neither. Engineering students used 'in-person only' the least, compared to a relatively even split of the other usages. The majority of Sports Sciences students reported they had used neither type of MSS.

Response numbers were then accounted for each discipline by converting the number of students in each usage group into a proportion of total discipline responses. This was with a view to explore usage by discipline overall. Here it was found that the discipline to have used both types of support the most was Education, HLS students used 'online only' the most, and Sports Sciences was the most common discipline in the sample to not have used MSS at all. Most commonly, 'In-person only' was the MSS

usage type not to have been used by disciplines, and between the disciplines that had, proportions were relatively similar.

5.4.1.2 Student usage

Prior to the student questionnaire, gatekeepers were given questions about what MSS services they provided, namely provision prior to and during the pandemic, and current provision. This was to give context to students' usage answers. Institution websites were also explored when additional context was needed.

All but one of the nine institutions had a dedicated centre for their MSS provision, a regular physical space not shared with other services. Drop-in support, appointment-based support and workshops were the most common provision offered both online and in-person. For in-person provision all institutions offered in-person drop-in, but only 66.7% offered appointment based one-to-one support. An additional 77.8% also offered workshops / tutorials. In general, 'tutorials' and 'workshops' seemed to be used synonymously, usually with tutorials just being smaller scale. However, some institutions also used the word 'tutorial' to describe one-to-one assistance with a tutor. Any additional context needed was provided by exploring their associated websites. For online provision, 66.7% of institutions offered drop-in support, and 77.8% offered appointments. All offered some form of online resources. This information was then used to help navigate student responses, and group them into provision types as fitting as possible.
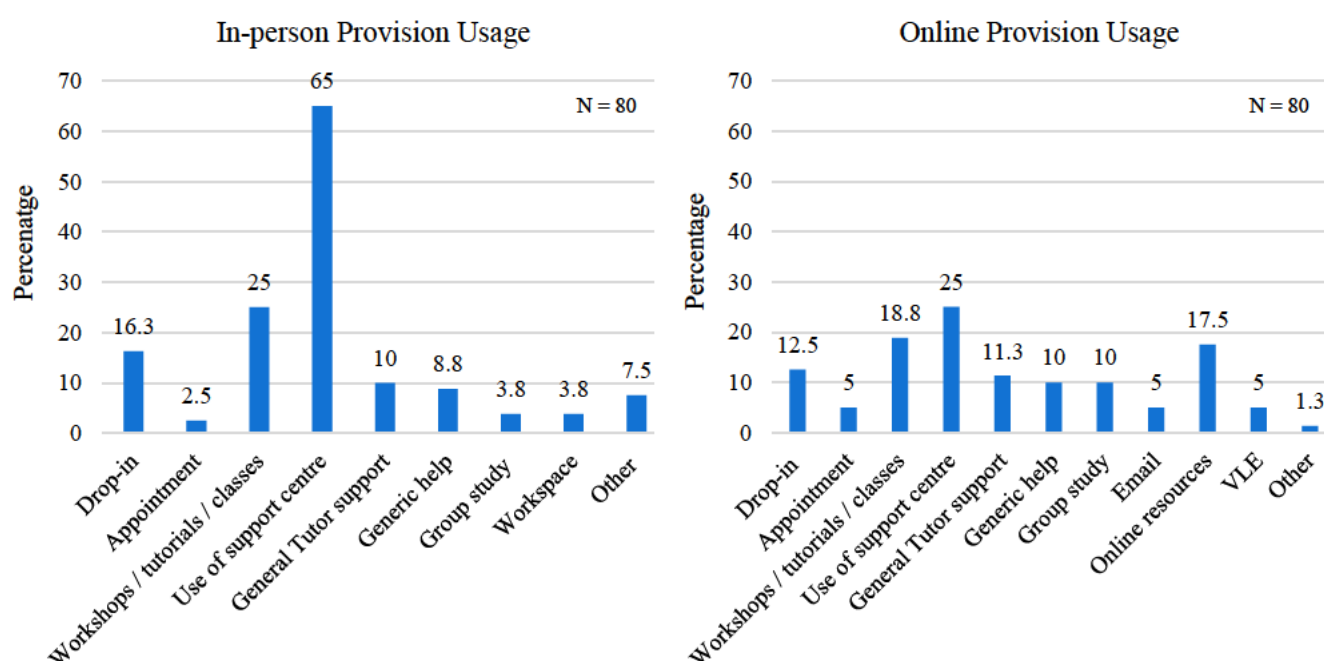
Figure 5.6 *Percentage usage of in-person (left) and online (right) support services reported by students who had used some type of MSS*

Students who stated they had used some form of MSS were asked what services they had utilised at their institution. Those who had used both types were asked this as two separate questions for in-person and online provision in turn. Responses were then gathered for in-person and online and grouped under umbrella terms. There were 80 students in total having used some form of in-person support, either solely or jointly, and 80 for online also, all of whom provided at least one service they had used. Figure 5.6 shows the percentage of those students having used each named service. It is important to note that students could have used multiple services and therefore percentages do not sum to 100.

The most common response to this question for in-person support, by a large margin, was students stating they had used their maths support centre (65%). Students tended to be non-specific in their answers and often did not provide detail on what they had used the centre for (a similar situation for 'generic help' and 'general tutor support'). Therefore, this usage does encompass many other services reported. It is likely that this meant drop-in support, as all institutions offered this with the majority having a dedicated centre to do so, however it could also include other uses of a support centre such as a workspace or appointments. 'Other' included programming support centre, tutor office hours and laboratory support, all 2.5%.

Online support services were used by students at a more similar level to each other, with the most common answer again being the use of their online maths support centre (25%). This was closely followed by workshops / tutorials (18.8%) and online resources (17.5%) which was mainly the use of videos. Here, 'other' was the use of Facebook messenger (1.3%). Group study was reported relatively rarely for both types of support.

5.4.1.3 *Student preference*

Students were then asked their reasoning for accessing that type of support. Again, students who had used both types were asked this in two separate questions for online and in-person support. Responses were collated across these questions and then grouped into themes. The questionnaire received 77 total responses about reasons for using in-person support, and 74 for online. The results can be seen in Table 5.2 along with the percentage of responses that mentioned each reason. Due to the nature of the question, students could have reported multiple reasons and therefore percentages do not add up to 100.

In-person (n = 77)		Online (n = 74)	
Reason for use	**%**	**Reason for use**	**%**
General statements of 'I needed help'	41.6	General statements of 'I needed help'	33.8
Ease of communication	15.6	It was the only option	25.7
More convenient and ease of access	15.6	Accessibility	17.6
The environment and sociability	14.3	Flexibility and convenience	14.9
Better understanding and easier to learn	11.7	Online support is easier	8.1
Online isn't as good	5.2	General positivity for online support	2.7
More engaged	3.9	It's fast	2.7
General positivity for in-person support	3.9	Anxiety	1.4
It was the only option	1.3	I don't like in-person	1.4

Table 5.2 Students' reported reasons for accessing in-person (left) and online support (right)

For both types of support, general statements of needing help were the most common response, where details were not given as to why they had chosen that mode of support over the other. *"I required support for algebra from a different perspective than from the lecturer"*.

Ease of communication was the joint second most frequently mentioned reason for using in-person support, reported by 15.6% of respondents, with reference to both verbal and written communication. Students generally felt everything could be seen more easily and therefore it was easier to ask questions and have their work checked in an in-person setting. *"It can be hard to communicate maths via a computer screen so it's easier to go in-person."* Conversely however, the second most common reason for students using online support was not positive towards the setting, only being used out of necessity due to in-person not being an option. Online support being the only option was mentioned by a quarter of online users. These included referring to the influence of the pandemic, in-person support not being offered, or illness. This suggests that if in-person support were available they would have used that mode, but the need for support outweighed the preference of setting. This implies that there is an underlying preference for in-person support than for online.

Ease of access was brought up for both modes of support, mentioned slightly more for online (17.6%) than for in-person (15.6%). For in-person support, students commonly felt that if they were there on campus and they needed support it was easily accessible to them and so they would use it. *"It is easily accessible at uni, and I study at uni every day so it [is] the simplest"*. This supports practitioners' concerns about loss of footfall created by online support. For online support, this encompassed any mention of being away from campus and not having to travel to access support. Just under half the responses in this category were from distance students living away from campus, including one abroad.

"*I live a 40-minute commute from college and have other obligations during the day. So, it helps me maximum* [sic] *the limited time I have*". The remaining responses explained the benefits of being able to access support from home, including not having to travel to campus when they did not have lectures which saved time and travel costs. Closely linked to this, as flexibility can increase access, flexibility and convenience of online support followed next, mentioned in 14.9% of responses. This category included specific mention of the times of online support being more suitable. It allowed for better time management around students' schedules making it more convenient for them to use.

The benefit of the physical environment of in-person support, and the social side that comes with that, was given as a reason by 14.3% of in-person support users. Students felt that productivity was increased by the environment, and many enjoyed being able to work around and with others. Some went on to explain that they could then receive help if and when required as they were already there. "*It is a productive workspace especially useful for between lectures. It's helpful to complete tutorials in there as you can ask for help when you encounter a problem.*" This is an interesting comparison to what was shown in in Figure 5.6, as workspace and group study were rarely mentioned as uses of in-person support, however this may just be due to specificity of answers.

Following that, 11.7% of in-person users stated that being taught in-person aided their learning as they had an increased understanding of concepts. Language used to describe their learning included "*better*", "*easier*", "*more*", and "*benefit*". This also included responses stating it was harder to learn elsewhere such as in an online setting or in lectures. "*It is much easier to learn face-to-face*". Comparatively, 8.1% of online users felt it was actually easier to use online support. Not including a couple of generic responses and one stating it was easy to book sessions, students felt productivity was the same or better online as they had everything in one place. "*Much more practical and I personally find learning easier by watching videos of someone explaining a topic*".

Both settings had generic positive comments about that mode of support, "*in-person works well for me*", "*because rehearsal videos are good*", with both also receiving negative comments about the other. This was more common for in-person support, with four students stating learning online is not as good, "*Because digital learning is soulless and terrible and DEPRESSING*", to only one online user expressing their dislike of in-person, "*Hate campus and generally university/student 'lifestyle'*". Interestingly both settings also had one student explaining how their depression (and anxiety for the online user) meant they could only access that type of support.

Additionally, students who had only used one type of support were then asked what had put them off using the other mode. Again, answers were grouped and can be seen in Table 5.3. Reasons for being put off from using a certain type of support generated similar themes to the reasons why students engaged.

What has put you off using online support? (n=25)		What has put you off using in-person support? (n=26)	
Reason	**%**	**Reason**	**%**
Prefer in-person	24.0	Online is easier / more convenient	26.9
More distractions	20.0	In-person wasn't available	23.1
Challenges with online support	20.0	Problems with timing	19.2
No reason	20.0	Negatives of in-person	15.4
Not knowing where to find it	8.0	Distance / Not wanting to travel	15.4
Other (3)	12.0	Haven't needed it	3.8

Table 5.3 In-person only and Online only users' reasons for not using the other mode of support

There were 26 responses from in-person only users of reasons for not wanting to engage with online support, and the most common was preferring in-person or disliking online. Reasons given were that online support was "*stressful*" and "*of little use*", being put off by "*impracticality*" and "*unfamiliarity*" and having to interact with a screen. Students preferred one-to-one support with a physical person.

More distractions, challenges with online support, and simply having no reason, were all mentioned the same number of times (20% each). Students felt that they were less engaged online, finding it harder to focus which resulted in more distraction. "*I find it difficult to understand and engage with online content*". Of a similar sentiment, challenges with online support that were mentioned included finding it harder to learn and understand, as well as communication difficulties, and using software being easier in-person. Students who stated they had no reason to use online support explained it was because they did not need it or had sufficient support elsewhere, with one having just not thought about using it.

The 'other' category included, burn out of online learning resulting from the pandemic, "*other students*", and the struggle to balance using online support from home and then getting to campus for scheduled teaching as there is not an appropriate place to access it from campus.

Online only users provided 26 responses in total for why they had not used in-person support, of which a quarter (26.9%) mentioned online support being more convenient. These were mainly general claims. However, one student explained they preferred the interactive whiteboard to pen and paper as it aided in reading handwriting, and another enjoyed the ability to watch videos "*whenever you feel like it*". This was closely followed by in-person support just not being available (23.1%), which mirrors the most frequently mentioned reason why students chose to engage with online support. One student specifically stated that they preferred in-person support but could not use it.

Timing and scheduling issues, namely the times in-person support was on did not suit their schedule, were reported in 19.2% of answers. One student explained that they preferred to know what time their slot would be so that they could plan out their day. This may have been due to their university not offering in-person appointments and therefore reflected on their opinion of in-person support in general.

'Negatives of in-person', mentioned in 15.4% of responses, included any issue with in-person support that had put students off. Two related to the busyness and availability of in-person support, "*Not guaranteeing I can see someone for all my questions*". The other two were possibly related to anxiety: "*the thought of 1 on 1 maths help is unsettling*" and "*don't want the person to ask me questions*". Mentioned the same number of times were students explaining that they did not want to travel to campus, particularly due to living away and the commute being too time consuming.

Finally, one student stated that they had no reason, just that they simply had not needed to use in-person support. In three other responses students also stated that they had no reason before then giving a reason that fits into the discussed themes.

The same students were then asked what would encourage them to use the type of support they had not utilised. This produced 22 and 25 responses from in-person only and online only users respectively, and their suggestions can be seen in Table 5.4.

To use online support (n = 22)		To use in-person support (n = 25)	
Encouragement	**%**	**Encouragement**	**%**
If necessary	27.3	Improved Availability	28
If online support improved	27.3	Change in provision	24
Nothing	22.7	If necessary	20
Confidence	13.6	Knowledge of the service	16
If it fitted into my schedule	9.1	When I can	12
Space to access it	9.1	Other (2)	8
Knowledge of the service	4.5		

Table 5.4 Exploring what would encourage in-person only and online only users of MSS to use the other mode of support

Some overlap was found between the two settings. Necessity was mentioned as an encouragement to use either type of support, meaning students would be encouraged to use it if they had to or had no other choice to. This was the joint topmost mentioned suggestion for engaging with online support (27.3%), "*If necessary for my circumstances at the time*", which again mirrors this ongoing preference for in-person support that the majority of students seem to have. However, it is also the third most mentioned

means of encouragement for engagement with in-person support (20%). This shows there are still some students who strongly value online, "*If they stop online services but even then, it's unlikely that I will go*".

A change or improvement to support was also brought up by both users. For using online support, factors that were mentioned needing improvement were engagement, structure, access, technology, and ease of use. "*I don't think I'd attend an online session unless the technology we used was greatly improved to allow maths to be better communicated both ways*". Whereas for using in-person support, they were mainly comments of wanting a change rather than explicitly stating wanting an improvement. There were six comments in this category (24% of total responses). Three wrote about the content of support sessions, two of which were about how they would only attend if specific topics were covered, and the other wanting engaging and friendly sessions. The remaining three wanted group sessions, live classes, and the ability to book, which obviously depends on what institution they belonged to and when they had utilised support.

Improved availability of in-person support was most frequently reported by online only users (28%), particularly wanting the guarantee of a slot. This is reflective of some of the comments of in-person support being too busy, or more of online support being pre-booked in comparison to in-person. Other comments wanted more suitable times to fit around their schedules, for some during the day around classes, and others in the evenings. One student belonged to a remote campus and wanted in-person support to be available to them. Similarly, this was mentioned by two in-person users about online support (9.1%) where they would only use it if they did not also have to attend classes.

For three in-person only users, confidence and knowing what to expect held them back. One student stated they needed confidence in their own abilities while another explained that if their friends from their in-person tutorial went then it would be easier. The final student explained that they had never been to an online session, so would need to try it out first to see.

Along similar lines as knowing what to expect, 16% of responses from online only users, as well as one in-person only user, felt they needed to know more about the other mode of service. Two of the online only users stated they needed more tailored information, specifically what would be beneficial to their own needs, delivered by their lecturers about what was on offer in-person. The other two explained that they needed to know more about the tutors and the experience itself. "*An in-person introduction to the staff who deliver sessions*", "*If I knew something about the tutors and the experience*". The one in-person user wanted a timetable of support emailed to them along with university updates so that they knew when it was.

For online-only users, there were two comments that fell into 'other', and these were that nothing would encourage them to use in-person support and wanting to be supplied with free cookies.

The final question exploring student preference was given only to respondents who stated they had used both forms of support and asked which mode of MSS they preferred.
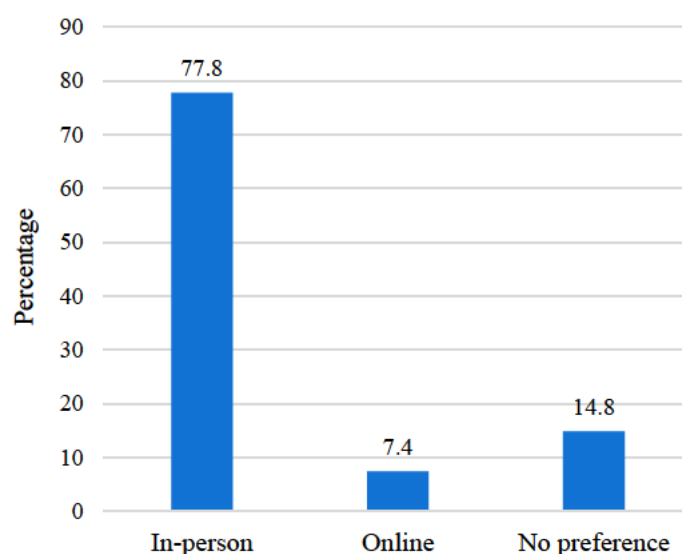
Figure 5.7 Preference of mode of support from students who have used both

Figure 5.7 shows that there was a clear preference for in-person support by students who had experienced support in both settings, with just over three quarters of those students having this opinion. This supports the underlying preference for in-person support being displayed in responses to questions discussed so far. However, and importantly, there are still students who highly value online support, with four respondents actually preferring that mode.

To explore this further, respondents were asked to explain why they had this preference, to which all 54 provided an answer. The 42 responses for an in-person preference were grouped, falling into four categories, and displayed in Table 5.5, and responses for the other preferences are summarised below.

In-person preference (n = 42)	
Reason	**%**
Ease of communication	37
Better learning experience	33.3
Sociability	20.4
Engagement	13

Table 5.5 Reported reasons for students preferring in-person support provision

All four themes of answers to why students prefer in-person support also arose in students' reasons for engaging with it, therefore highlighting which reasons were most important to them.

Ease of communication in an in-person setting was the most frequently provided reason for preference, most commonly how it is easier to ask questions (40% of responses in the group) or to ask in general (15% of responses in that group). *"It's easier to communicate. I can point to things in the book, I can show resources. In-person for me is always best. Online is just something to use when in-person isn't practical or available"*. Not including general statements of using support because they needed help, this was also the most common reason why students engaged, which suggests that communication is the most important quality of support to students.

Across the in-person themes, a few students also brought up the ability to be read by a tutor and how they can more easily see when a student is struggling: "*Deeper understanding of students confusion / anxiety about misunderstanding*".

Of the four students who preferred online, three stated online support was easier. Reasons provided were getting to go at their own pace, asking questions and convenience of receiving support at home, and access and fitting in, presumably with scheduling. It was interesting to see the conflict between the students who preferred in-person support because they thought question asking was easier and a student who felt this was actually true for online. Additionally, the final student explained their question asking was more organised because booking required them to provide it beforehand. This is reflective of an advantage of online support that a practitioner proposed during the exploration in Chapter 4 for the same reason, that students come to support more prepared and focused in an online setting. However, this may be influenced by an institution offering bookable support more than or over drop-in support online, particularly during the pandemic, and therefore reflected on their opinion of online support in general. This final student also felt that tutors were more focused in an online setting too, "…*I find the tutor more focussed as they have no other distractions but helping me*".

There were three types of answers from students who stated they had no preference. Three students felt simply that both types of support worked similarly for them. Three students stated both types of support have different advantages. Online support advantages mentioned were ease of access, and anonymity while exploring how support worked along with getting to know some of the people attending. For in-person, these were that, again it is easier to understand in-person, and the ability to talk to people and form study groups. The final two used which ever mode was best suited for their advancement at the time. "*I like both depending on what way I'm studying. If it's newer stuff that I'm having trouble with I prefer in-person and if it's old stuff that I need to go back over myself I prefer online*".

Looking at answers to this question overall, a mode of support being easier over the other tended to be the most common reason dictating a students' preference. Just over half the total responses for this question (53.7% of 54), regardless of preference, stated that either mode was easier in some way.

5.4.1.4 Non-engagement

Students who stated they had not utilised support were given a list of reasons that had regularly been reported why students do not access support and asked to select each that applied. The result can be seen below (Figure 5.8).
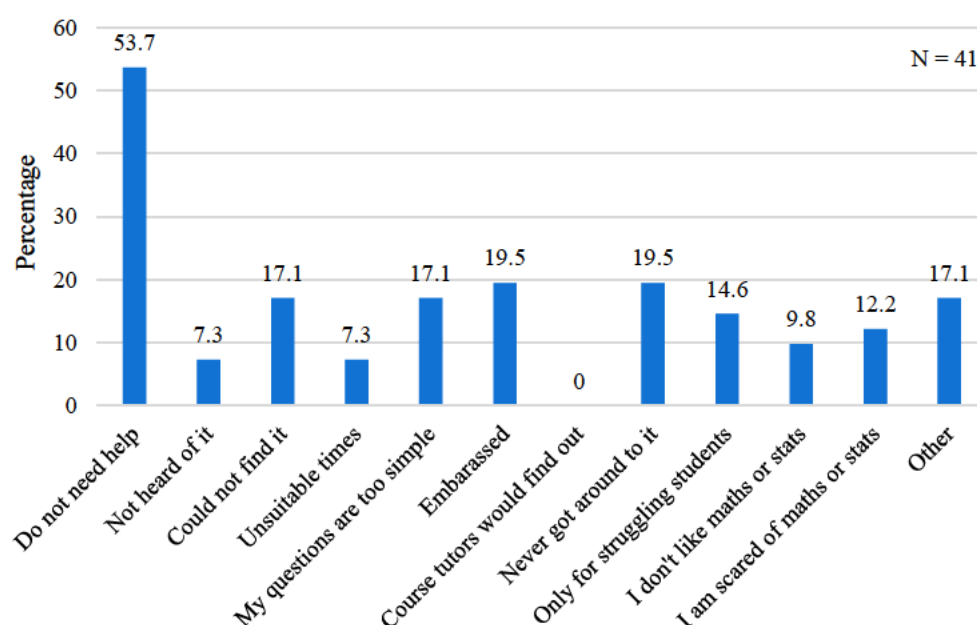
Figure 5.8 Percentage of responses to 'Why have you not accessed mathematics and statistics support services at your university?'

The most common reason non-engagers gave for not accessing MSS (just over half the responses received for this question) was that they did not need help. This is to be expected as not all students require extra assistance, and for some that do they seek it elsewhere.

Not getting around to it was selected by 19.5% of students. This suggests that there are students that have struggled enough to consider using support and thought about doing so, but nothing had brought them to actually use it. Additionally, two comments provided in 'other' were variants of this reason, namely not having gone yet but planning to, and support not being a priority due to laziness. Including these two responses, this would increase the number of times this reason was chosen to 10 (24.4%), making not having gotten around to using support the most common reason for not engaging, after not needing support. This result may be an example of students hiding their real reasons for not engaging, particularly as affective reasons were chosen at a similar level by students.

The disliking and fearing mathematics and statistics options were chosen by 22% of students in combination, both of which can be traits of mathematics (and statistics) anxiety (Meece (1981) as cited in Wigfield & Meece (1988)). This was closely followed by embarrassment (19.5%), which was joint second most frequently chosen reason for non-engagement when not combined with any other option.

In relation to this, the joint third most frequently selected reason for non-engagement was feeling that their questions were too simple (17.1%). This is similar to embarrassment in that some students fear that they are going to look stupid, or have their mathematical or statistical ability revealed, if they ask questions that they feel they should already know the answer to. These results are an encouraging outcome in terms of the honesty of participants, as anxiety and feeling embarrassed is often considered deeper reasoning, as they are in the affective domain. Interestingly, this contrasts with the findings of Symonds et al. (2008), who found almost exclusively procedural reasons, such as not knowing where the support was. This is discussed further in Section 5.5.

'Other' included, teaching oneself instead, being away from campus due to COVID, and two students feeling their ability was holding them back as they did not know what they did not know. Two students also stated they did not know about the service, one of whom did not also select this as an option.

Furthermore, as discussed in Section 5.2.1, engagers with MSS were asked why they thought other students were not engaging, in the hope of receiving more affective reasons. These responses were summarized (Table 5.6) and compared to those given by non-engagers thereafter. The number of respondents to this question in each MSS usage group is shown. It is important to note again that the percentages do not add up to 100 as some respondents gave multiple responses within their answer, and some responses could be sorted into multiple groups.

In-person only (n = 21)		Online Only (n = 22)		Both (n = 39)	
Reason	%	Reason	%	Reason	%
Unaware (advertising issues)	47.6	Unaware (advertising issues)	40.9	Students feeling shy, scared, or embarrassed	53.8
Students feeling shy scared, or embarrassed	28.6	Students feeling shy, scared, or embarrassed	27.3	Unaware (advertising issues)	33.3
Only for Mathematics students	19	Unsuitable times	18.2	Motivation	20.5
Unsuitable times	14.3	Takes up too much time / not worth their time	13.6	Don't need / want it	15.4
Don't need / want it	4.8	Not knowing people	9.1	Unsuitable times	7.7
		Don't need / want it	4.5	Not knowing people	5.1
				Only for Mathematics students	2.6

Table 5.6 Reasons for non-engagement of peers proposed by students who had engaged with MSS

For students who had accessed both types of support, their most suggested reason for their peers not engaging, present in over half of responses (53.8%), was students feeling shy, scared, or embarrassed. "*The*[y] *don't feel safe going, in the sense that it is not a safe space, and they feel embarrassed for asking for help. There is a large expectation for self-study in uni and if we can't do it ourselves, we feel*

like we are failing". This was also the second most suggested reason by students who had only used one type of support. "*It's easier to survive in silence th*[a]*n ask for help*". As embarrassment was not chosen as frequently by non-engagers, this suggests maybe more students are embarrassed than want to admit it.

For students who had only used one type of support, the most proposed reason was peers being unaware of MSS services, particularly as a result of advertising issues. These included circumstances such as having never heard of support, not knowing where to find it, not knowing what to expect, or being unaware of the benefits. "*Unaware of how good the service actually is and not realising that it's worth their while*". This was also second most frequently mentioned by those who had engaged with both types of support. The opposite ordering seen for the two most frequently mentioned ideas, may be due to users of both having managed to discover how to use both forms of support, and therefore do not think as negatively on the availability of information.

Comparing this to what non-engagers said, looking back at Figure 5.6, not hearing of support and not knowing where to find it, were both supplied as separate options for non-engagers to choose as their reason for doing so. In combination, with the additional student who stated they did not know about the service for 'other', this lack of awareness applied to 26.8% of non-engagers. This would make advertising issues the most common reason for students not accessing support, after not needing it. One student although having engaged with support even exclaimed, "*I have no idea what support is available! Nor where to go for it! It's probably just me being a dumbass but I have no idea where to go!*".

The majority of options provided as choices to non-engagers were brought up by users of MSS. It is important to note that students who engaged could not see the question given to the non-engagers and so responses could not have been copied from the options that were provided.

Interestingly, although the question stated that there are some students who would benefit from support but are still not accessing it, all three usage groups still mentioned that these students may feel they don't need or want it. This suggests there's a possibility that some of the 53.7% of non-engagers who stated this was the case may be those who would benefit from support but have convinced themselves otherwise. This is very similar to what O'Sullivan et al. (2014) found, where approximately of the two thirds of students who were not engaging with MSS, half was because they did not need to, and the other were not engaging but may have needed to.

All three types of users also brought up unsuitable times, reflective of reasons for engagement discussed earlier. "*Sometimes the classes offered clash with other lectures/tutorials/labs for other modules*". However, disliking or fearing mathematics or statistics, or anything related to mathematics or statistics anxiety, was not. Anxiety in general was only mentioned five times by any user (6.1%) and only in

general statements of being anxious about going to support or failing. This may suggest that students are not that aware of mathematics and statistics anxiety.

Motivation and feeling support is not worth their time ties into the 'effort' theme of answers produced by practitioners in the previous chapter. Likewise, students felt that peers might not be engaging due to not 'being bothered' or having more important things to do with their time. "*I think they just don't put in enough effort*". This is potentially more reflective of students who would not fail without MSS yet would not achieve their full potential either. "*They honestly don't care and just want a pass in maths*", "*...some students wouldn't have the want for better results*". This is discussed more in Section 5.5.

Overall, for many responses, the aim of this question worked in that students were giving numerous affective reasons with several including themselves in what they were saying, using pronouns such as 'we', 'I', and 'you'.

5.4.1.5   *Advertising*

Participants, regardless of MSS use, were asked in separate questions to rate on a five-point Likert scale how good/successful they thought the advertising of in-person and online MSS was. The results are presented in Figure 5.9 below. This was followed by a requirement to explain their choice, before being provided with an opportunity to suggest improvement strategies. These responses are summarised in Tables 5.7 and 5.8.
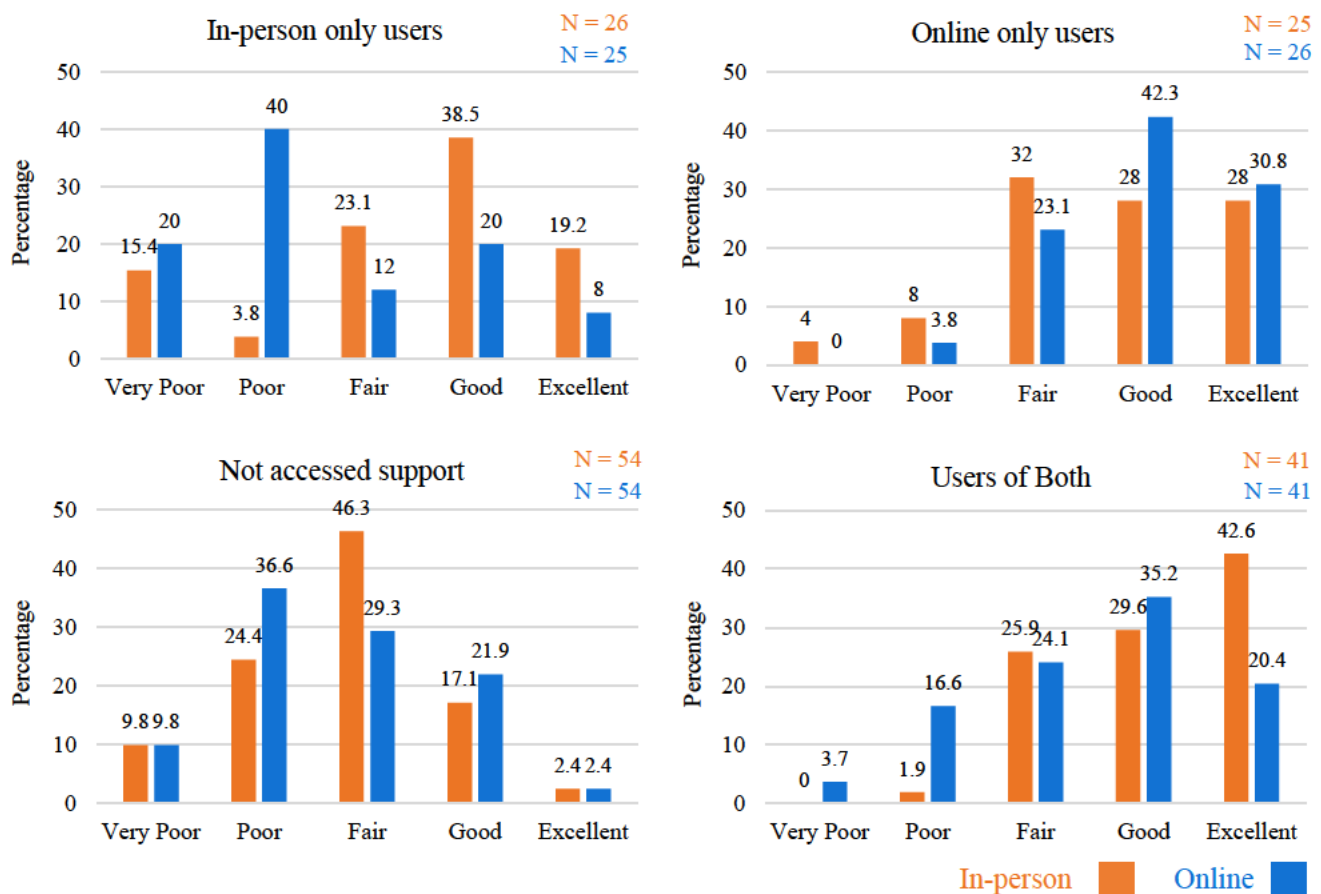
Figure 5.9 *Bar graphs depicting the answers given to 'How good/successful do you feel the advertising for in-person / online MSS services is?' by participants of all four user types*

Note that one respondent in both of the 'only' usage groups rated advertising for only the type of support they had used, hence total number of responses here is 146.

Figure 5.9 shows a comparison of what students thought about the advertising of in-person MSS services to the advertising of online services, separated by their usage type. Generally, opinion of adverting aligned with the type of support the students had used. Both the groups who had only used one type of support rated advertising for that mode higher than the other. In-person only users rated advertising of in-person support much more highly than that for online. Online-only users were more positive of advertising of in-person support, but still rated advertising of online support slightly more highly. Users of both methods of MSS rated advertising of both modes relatively highly, with advertising for in-person services slightly higher. Finally non-engagers did not rate advertising for either mode particularly well.

Overall, looking at the 146 responses as a whole, advertising of in-person support was thought of more highly. 15.8% rated advertising for in-person support as 'Very poor' or 'Poor' compared to almost

double that (31.5%) for online support advertising. Likewise, 52.1% rated advertising for in-person support as 'good' or 'excellent' compared to a lower 45.2% for online support advertising.

The highest praise for advertising of online support came from online only users, whereas for in-person support advertising it was from students who had used both types. Online only users also gave the most praise for advertising in general, very closely followed by users of both. Users of both were the only group of students to frequently mention motivation as a potential reason for non-engagement (see Table 5.6), suggesting they are more critical of the non-engager as opposed to the support itself.

Students were then asked to explain their choice of rating. Reasons were explored across the questionnaire as a whole based on what rating the student had given. Responses could be categorised into groups, and these are displayed in Tables 5.7 and 5.8 for advertising of in-person and online respectively. Reasons generally only fit into one category, but where percentages do not add up to 100 it is because a few responses fit into multiple. Responses that were not to do with advertising were not included in the analysis, but it is important to note that 16 reasons for giving an 'Excellent' rating to advertising was praising MSS directly as opposed to the advertising.

Reasons for ratings given to advertising of in-person support									
Very Poor (n=7)	**%**	**Poor** (n=13)	**%**	**Fair** (n=43)	**%**	**Good** (n=39)	**%**	**Excellent** (n=24)	**%**
Haven't seen any / unaware	85.7	Haven't seen any / unaware	53.8	Minimal advertising	41.9	It is frequent / multiple methods	30.8	It is good quality	50
Minimal advertising	14.3	Minimal advertising	23.1	Some advertising	27.9	It is good quality	25.6	It is frequent / multiple methods	41.7
		Lecturers need to say about it more	15.4	It is frequent / multiple methods	18.6	It could still be better	17.9	I know about it	8.3
		Used as a threat	7.7	I know about it	16.3	Generic mention of a method	12.8		
				Haven't seen any / unaware	2.3	I know about it	10.3		

Table 5.7 Reasons students provided for giving each rating on a five-point Likert scale of advertising of in-person MSS services

Reasons for ratings given to advertising of online support									
Very Poor (n=10)	**%**	**Poor** (n=33)	**%**	**Fair** (n=30)	**%**	**Good** (n=34)	**%**	**Excellent** (n=16)	**%**
Haven't seen any / unaware	80	Haven't seen any / unaware	51.5	Minimal advertising	40	Some advertising	44.1	It is frequent / multiple methods	43.8
Minimal advertising	20	Minimal advertising	42.4	Some advertising	26.7	General positivity	20.6	It is good quality	43.8
		Requires searching for	6.1	Haven't seen any / unaware	13.3	It is frequent / multiple methods	17.6	I know about it	12.5
				I know about it	13.3	Minimal advertising	14.7		
				It is frequent / multiple methods	10	I know about it	2.9		

Table 5.8 Reasons students provided for giving each rating on a five-point Likert scale of advertising of online MSS services

Interestingly, the ratings students gave were mostly dictated by frequency of advertising, for example, how much advertising was seen, how often they were told, and how many students knew about the service, rather than an opinion on the type or quality of advertising. There were four main frequency categories:

- **Haven't seen any / unaware.** "*I have never seen any and I don't know what it is*". If a student stated that didn't know what MSS was, or the services on offer, it was assumed they had not seen any advertising. Most common for 'Very Poor' and 'Poor' ratings.

- **Minimal advertising.** "*I have only seen limited advertisements at the beginning of my course in my first year*". Students explained that they had seen advertising, occasionally mentioning one form such as word of mouth or emails, but it was limited. Most common for 'Fair' and 'Poor' ratings.

- **Some advertising.** "*...all the info is there but needs more signposting*". Generally, comments were more positive than those in the previous frequency category. Included statements that a number of students are aware of MSS services, but not all. Most common for 'Fair' ratings and 'Good' for online.

- **Frequent / multiple methods.** "*Emails are sent to students every week saying services are available for extra support*". Students felt they were regularly updated or reminded that support services existed, or that there were multiple forms of adverting. Most common for 'Excellent' and 'Good' ratings.

They each appeared as reasons for at least two of the ratings. The more frequent students thought advertising was or the more student they felt were aware of the service, the higher the rating.

The quality of advertising was still brought up in some responses however, but only by those who gave a 'Good' rating for advertising of in-person services or an 'Excellent rating for both. "*Advertised to me in my lectures, made it feel very accessible and aware straight away*". This group of responses also included statements about most to all students knowing of their institution's MSS services, "*I can only assume that it is successful because it is always filled with students*." This suggests that students only notice the quality of advertising if there is enough of it around to see.

Three students made a direct comparison of online support advertising to the advertising for in-person support saying they felt in-person was advertised more, "*I didn't really no* [sic] *much about it, bc* [sic] *its bigger focus on in-person*", or the focus had decreased after the pandemic.

Respondents then had the opportunity to suggest improvements for advertising. As advertising for in-person support and online support were rated differently it was important to look at what improvements students had suggested for the two modes separately. Those ideas can be seen in Table 5.9 and Table 5.10 respectively.

In-person advertising (n=97)	
Improvement	**%**
More in frequency / quantity	32
Utilise lecturers / advertise in lectures	19.6
No improvement / Cannot be improved	14.4
Improve content / quality	11.3
Use of Social media	9.3
Use of Posters	8.2
Use of VLE / Website	8.2
Advertise at the beginning of year / term / module	8.2
More targeted advertising	7.2
Use of Emails	7.2
Advertising to make MSS more approachable	5.2
Verbal advertising	2.1
Other (7)	7.2

Online advertising (n=81)	
Improvement	**%**
More in frequency / quantity	19.8
Improve content / quality	17.3
Use of Emails	17.3
Utilise lecturers / advertise in lectures	14.8
No improvement / cannot be improved	14.8
Use of VLE / Website	13.6
Use of social media	9.9
Use of Posters	8.6
More targeted advertising	7.4
Advertise at the beginning of year / term / module	4.9
Verbal advertising	2.5
Other (7)	8.6

Table 5.9 Suggested improvements to advertising of in-person MSS

Table 5.10 Suggested improvements to advertising of online MSS

The most common response for improving the advertising for both modes of support was wanting more frequent or an increase in quantity of advertising. Some students mentioned specific types of advertising they wanted to see more of, most commonly verbal advertising during lectures closely followed by emails. Others just expressed it was simply not advertised enough, "*more consistent advertisements and reminders*". Additionally, wanting improvement to the content or quality of advertising was the second most common reason for online support and fourth most for in-person. Students particularly wanted more thorough information about what services are on offer, giving more specificity and clarity. "*Perhaps make it clearer the specific type of MSS services available as well as detailed instructions on how to use them.*" Some students wanted this to go even further, explaining exactly what there is to expect, the advantages and disadvantages of using MSS, and why they would want to use it. "*Explain what kind of help can be given and what this help will look like (one-to-one, minutes, etc.)*". Unsurprisingly, these two groups of suggestions reflect that the most common reason for non-engagement, after not needing support, was advertising issues. It also mirrors students who had only used one mode of support explaining they needed more information on the opposite mode before they would engage with it. Yet it was interesting to see that statements expressing that improvements were not necessary were relatively common.

Utilising lecturers or advertising within lectures was a popular suggestion for both types of support. Students mainly explained they wanted lecturers to provide them with information or push attendance to MSS more within their lectures, mainly verbally. "*Get more lecturers involved and promote it more in class*". Two students also suggested that the tutors themselves come in to advertise. "*Perhaps a tutor from the centre could do a quick 3-5 minute presentation/promotion in the introductory lectures or sessions of modules that may require support*". These comments were additional to the students who explained they would be encouraged to engage with online support if they knew what to expect by getting to know the support tutors beforehand, reported earlier.

Students mentioned wanting online methods of advertising more frequently for online support than for in-person, namely use of emails, social media, and VLE / website use. There was particular reference to the provision of easy access links at the top of their institution's VLE pages, or in emails they received, to make getting to the support quicker and easier. "*Regular and timely emails, and links that are accessible at the top of each maths module page on Moodle*". This is further evidence of students' want of ease that has been an underlying theme in responses to questions so far, for example ease of use, access, learning, and communication.

Suggestions of targeted advertising were about adverting for those who need it, tailoring it to different audiences. Struggling students, non-mathematics students, and different year groups were all suggested audiences to target, with one student wanting advertising on an individual level, tailoring it to their personal experience. "*Possibly more through the modules that might require additional maths support*". This links to the only improvement not mentioned for advertising of both modes of support, which was adverting in a way that makes MSS seem more approachable, only suggested for in-person support. Students who provided responses in this category wanted advertising to make non-engagers, for instance those who are struggling or dislike mathematics, to feel that support is also for them. "*I think we should be introduced to the people who offer this support at the start of term, to remove the taboo around asking for support but also to make it clear that they are there for the students*". This ties in with the shy scared or embarrassed theme of why students were not accessing support.

Finally, there were seven single suggestions each for improving advertising of both modes of support. For in-person these included: tying advertising in with university advertising; creating videos; a dedicated MSS module / lecture; hold mathematics-based events; improve communication of timetabling; generic advertising around campus; and not using a threat as advertisement. For online support these were: quizzes with prizes; tying advertising in with university advertising; a dedicated MSS module / lecture; information of MSS being included on the syllabus; create videos; stop using 'round robin' emails (mass email sent to everybody regardless of how applicable to all recipients it is); and making it humorous and fun.

Advantages and disadvantages

Students who had indicated they had used MSS were asked their opinion of the advantages and disadvantages to both modes of support, regardless of what type they had used. Once blank or non-associated answers were removed, responses were grouped under common ideas, and these can be seen in Tables 5.11 and 5.12 for in-person support and online support respectively. Many advantages given for one type of support were also given as disadvantages for the other.

In-person support			
Advantages (n = 64)	**%**	**Disadvantages (n = 37)**	**%**
A better learning experience	37.5	Busyness / availability	29.7
Ease of communication	35.9	Have to be there / commuting	18.9
Sociability and Interaction	31.3	Scheduling issues	18.9
Benefits of the physical environment	12.5	Harder to learn	13.5
Faster	7.8	More uncomfortable	13.5
General comments of 'It's helpful'	6.3	More time consuming	10.8
Other (5)	7.8	Other (4)	10.8

Table 5.11 Advantages and disadvantages of in-person MSS proposed by all MSS users

Online support			
Advantages (n = 53)	**%**	**Disadvantages (n = 53)**	**%**
Accessibility	50.9	Harder learning environment	39.6
Flexibility and availability	22.6	Communication	28.3
Asynchronous resources	11.3	Technology and software issues	22.6
Better learning environment	9.4	Sociability and interaction	11.3
Quicker and easier	9.4	Issues with availability	9.4
General comments of 'It's helpful'	5.7	More uncomfortable	7.5
Other (3)	5.7	Slower	3.8
		Other (4)	7.5

Table 5.12 Advantages and disadvantages of online MSS proposed by all MSS users

The fact that there were more responses talking about the benefits of in-person support (64) compared to online (53), and more responses talking about disadvantages of online support (53) compared to in-person (37), supports that most students prefer in-person support. Again, there was overlap in themes produced in other questions, but this further highlights aspects of support most important to students.

In-person support being a better learning experience, particularly the influence on their understanding, has come up in students' reasons for engagement, their reasons for preference, and now the most

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frequently mentioned advantage to in-person support and disadvantage to online. Students provided the same reasons as reported earlier, such as finding they have better understating, focus and engagement, but also some new reasoning like getting more out of in-person support and it being a more tailor-made experience. However, other students, albeit a smaller number, felt the opposite. 10 students felt online support was the easier learning environment, or in-person was harder. They explained that it is easier to concentrate online as there is less noise, and therefore less distraction, because they are guaranteed to have no other students around. Therefore, both parties are more focused and so complex material can be conveyed better. As ease of learning seems to be one of the most important aspects of support to students, these conflicting opinions emphasises that there are still a small number of students who prefer online support and learn better in that environment.

Communication, sociability and interaction, and benefits of the physical environment were all also brought up again. Responses in these themes conveyed high value of physical and verbal interactivity with people in-person, both with other students and the tutors. It allowed them to build relationships, unlike online support where some (11.3%) felt that there is a lack of connection. "*It is quite lonely and you don't have the peer support like in-person*". Again, students explained that problem areas and questions can be communicated and interpreted more easily, and writing and sharing mathematics is less complicated. "*It's definitely easier to communicate face to face. If I wanna* [sic] *express what I'm having difficulty with, it's easier when you can get an idea of who you're talking to, so you know how to phrase it*". More students also brought up the benefits to tutors, explaining that they could read their students and get their points across more. Three of the eight responses that stated benefits of the physical environment talked about not having to deal with technological issues when receiving in-person support. This mirrors the 22.6% of online disadvantages that explaining technological or software issues they had experience, such as broken microphone, lag, screen quality and Wi-Fi issues.

Accessibility was the most mentioned benefit to online support, brought up in half of the responses to the question and the largest proportion of answers out of all the themes that arose. Likewise, 18.9% also stated this as a disadvantaged to in-person support. By far the most common reasoning was that online support can be accessed from outside the university and so students do not have to travel. Distance learners, students with disabilities or illness, and mature students with busy schedules were all referenced as groups benefiting from this. "*Can get help even if you're not near the university, more accessible to those with issues getting to the university like those with disabilities*". Students also mentioned how online support allowed MSS to continue during the pandemic, and screen sharing access.

There seems to be some debate about which mode of support is most efficient in terms of time. Speed of support came up as both an advantage and disadvantage for both modes. The most frequent instance of this was in-person support being more time consuming (10.8% of responses). These students felt that

it is more challenging and takes up considerably more of their time to both arrange and go to support in-person than it does online, support hours often clashing with university contact hours, or personal life commitments. However, 7.8% felt that once there, getting support was much more instant and efficient. Conversely, 9.4% of responses to advantages of online support felt these reasons were actually true for online, in that it is less time consuming and handier to access that mode of support. But two people also felt getting answers was slower.

Flexibility and availability were mentioned from multiple viewpoints as well. For the most, it was brought up as an advantage of online support (22.6%). Half of these responses used 'convenient' to describe online support, particularly with fitting into their schedules and the ability to access it at a time that suited them. "*...probably attend more sessions online than in-person, easier to attend*". The asynchronous options associated with online support closely links to this, as what was most important to these students (11.3% of responses) was how when material is recorded or slides provided, support can be accessed in their own time as much as they like.

However, students also found difficulty of appointment availability in both settings. This was the largest disadvantage to in-person support (29.7%), where the busyness of the service often meant a student could not see the tutor they wanted to. "*It's very busy, especially for popular academics which results in long queues and they don't have academics there for very long periods each day*". This was reasoned as being a result of staffing, capacity, and the time slots available. For online support, again there were complaints of the desired staff member not being available, and difficulty in accessing online support at an appropriate time when on campus. This was seen in Mullen et al. (2023) where 33% of 55 online-only users and 100% of 130 in-person-only users stated timetable suitability would make in-person support more attractive.

Finally, there were single advantages and disadvantages mentioned by one respondent for both modes of support. For in-person advantages these were the ease of use and scheduling (in contrast to opinion mentioned prior), stating in-person support only has advantages, and mathematics only being possible in-person. For disadvantages these were the COVID-19 pandemic, sessions being non-specific, and in-person support being "*heavy*" to deal with among other life commitments.

For advantages of online support, the single mentions were sharing a screen made it feel like they were in-person, cutting transport costs, and online being fine if in-person wasn't available. The disadvantages were that online support is less personal, the sessions are shorter, that online support's success is dependent on the online skills of the tutor, and that online support is only good as additional support to in-person provision.

Once themes of advantages and disadvantages had been identified, these themes were then also broken down by usage type to explore if there was any difference in opinion based on the type of MSS the students had used. This was particularly important as there were more students who had used both

modes of support than those who had only used one, and so their opinion would have had more of an influence on the themes overall. The result can be seen in Tables 5.13 and 5.14 respectively for in-person and online support. Themes now only mentioned by one student, including the 'other' category, are pointed out using an asterisk (*).

In-person Only				Online Only				Both			
Advantages (n=20)	%	Disadvantages (n=11)	%	Advantages (n=9)	%	Disadvantages (n=10)	%	Advantages (n=35)	%	Disadvantages (n=16)	%
Ease of communication	40	Busyness / availability	45.5	Ease of communication	55.6	More time consuming	30	A better learning experience	42.9	Scheduling issues	37.5
Sociability and Interaction	30	More uncomfortable	18.2	A better learning experience	44.4	Busyness / availability	20	Sociability and Interaction	31.4	Busyness / availability	25
A better learning experience	25	Have to be there / commuting*	9.1	Sociability and Interaction	33.3	More uncomfortable	20	Ease of communication	28.6	Have to be there / commuting	25
The physical environment	20	Scheduling issues*	9.1	Other (1)*	11.1	Have to be there / commuting	20	The physical environment	11.4	Harder to learn	18.8
'It's helpful'	15	Other (3)*	27.3			Harder to learn	20	Faster	8.6	More uncomfortable*	6.3
Faster	10							'It's helpful'*	2.9	More time consuming*	6.3
								Other (4)*	11.4	Other (1)*	6.3

*Table 5.13 The identified advantages and disadvantages of **in-person** support broken down by MSS usage groups. * Only mentioned by one student*

In-person Only				Online Only				Both			
Advantages (n=12)	%	Disadvantages (n=12)	%	Advantages (n=17)	%	Disadvantages (n=14)	%	Advantages (n=24)	%	Disadvantages (n=27)	%
Accessibility	58.3	Harder learning environment	58.3	Accessibility	41.2	Harder learning environment	28.6	Accessibility	54.2	Harder learning environment	37
Flexibility and availability	16.7	Communication	25	Flexibility and availability	29.4	Communication	28.6	Flexibility and availability	20.8	Communication	29.6
Asynchronous resources*	8.3	Technology and software issues	25	Asynchronous resources	11.8	Technology and software issues	21.4	Asynchronous resources	12.5	Technology and software issues	22.2
Better learning environment*	8.3	More uncomfortable	16.7	Better learning environment	11.8	Issues with availability	21.4	Quicker and easier	12.5	Sociability and interaction	14.8
Quicker and easier*	8.3	Issues with availability*	8.3	Quicker and easier*	5.9	Sociability and interaction	14.3	Better learning environment	8.3	Issues with availability*	3.7
		Slower*	8.3	'It's helpful'*	5.9	Other (2)*	14.3	'It's helpful'	8.3	More uncomfortable*	3.7
		Other (1)*	8.3	Other (1)*	5.9			Other (2)*	8.3	Slower*	3.7
										Other (1)*	3.7

*Table 5.14 The identified advantages and disadvantages of **online** support broken down by MSS usage group. * Only mentioned by one student*

Students of different usage groups were much more in agreement about the advantages and disadvantages of online support than they were of in-person. For advantages and disadvantages, the top three most commonly mentioned themes, either alone or joint with others, are the same for each usage group. This is also very similar to the order of importance of advantages and disadvantages students as a whole produced, shown in Table 5.11.

There were some small differences, however. Accessibility was not mentioned quite as frequently for online only users as the other two usage groups. Flexibility and availability was mentioned slightly more and as a result, availability issues were more important to these students. Asynchronous resources were valued less by in-person only users than the other usage groups, and all but one response stating that online support is more uncomfortable came from these users.

For in-person support there was a lot more disagreement. For users who had only used one mode of support, ease of communication was the most frequently mentioned advantage, but for users of both, this was only third. The most important advantage to these students was a better learning experience, which was only second or third most commonly mentioned for the others. For disadvantages, all three usage groups had a different theme mentioned the most. For in-person only users this was busyness and availability, having been mentioned quite a lot more than the theme in second position. For online only, in-person support being more time consuming was the most frequently mentioned disadvantage, but only by one mention, the rest were all mentioned the same number of times. All but one response in this theme belonged to these students. Finally, for users of both, the most frequently mentioned disadvantage for in-person support was scheduling issues, where all but one of the responses in this theme came from these students. Online only users did not mention any benefits of the physical environment.

Finally, it is interesting to note the number of responses given for advantages and disadvantages of the two modes of support within each usage group. For online support, these were relatively the same, only a minor difference within online only uses and users of both. However, for in-person support, in-person only users gave nine more advantages than disadvantages, and users of both gave over double the number of advantages than disadvantages. This suggests that for in-person support, advantages have more of an impact on these users than the disadvantages, but for online users, as well as all users in their opinion of online support, both advantages and disadvantages have the same importance.

5.4.1.6 *Final thoughts*

All students, regardless of usage, were asked what support methods they would like to see offered in the future. In total, 83 responses were received across the questionnaires, of which 33 were students stating that there were not any, eight were unsure, and 10 were un-associated comments or comments about university teaching in general. Hence 32 responses remained suggesting improvements students wanted to see. Unfortunately, only two suggestions came from students who had used neither type of

support. Also, six of the eight students who stated they were unsure, and the largest percentage of students who did not give any response to the question (45.3%), were also non-engagers. This suggests non-engagers do not know what would help them to engage.

Suggestions were grouped and displayed in Table 5.15 below.

MSS improvement	%
More specialised help	31.3
More asynchronous resources	21.9
More provision	18.8
Change of mode	15.6
More group work opportunity	9.4
Improved advertising	6.3
Other (3)	9.4

Table 5.15 Student suggestions to what they would like to see from MSS in the future

The improvement students wanted to see the most was more specialised help, which could be broken up into three areas. The most common was specific discipline help, where students felt they needed more support for different subjects other than mathematics. "*A larger variety of tutors i.e., physics, chemistry, etc...*". However, one student also wanted the opposite and felt there was not the same level of support for maths students. The other subgroups were more help with the use of software, such as SPSS, MATLAB and Abaqus, and specialised help for different abilities, "*Provide support for basic help as well as harder maths*". Finally, one student proposed having a dedicated tutor that they met with on a regular basis throughout all years of their study.

Providing more asynchronous resources followed second (21.9%), mainly online videos, where again the ability to access content at a time that suited them was highlighted. Other suggestions were practice sheets or quizzes, and exam solutions, with two wanting some form of resource addressing common challenge areas and mistakes. "*More worked examples and resources for teaching common difficulties students face. Why not have a recorded lecture explain*[ing] *how e.g., substitution for integration works. It'll be there forever and would help students more as many are lost on the actual mechanics of the maths and not the concepts*".

Some students wanted an adaption of current provision. This was either wanting more of the same thing, or a change of mode of services already available. 'More provision' consisted of two requests for longer opening hours, and three requests for more of a particular support method on offer, namely one-to-one appointments, holiday revision sessions, workshops on problem areas, and just wanting more help in

understanding content. Students requesting a change of mode mainly wanted in-person variants of online support provision, such as drop-in, appointments, and workshops, but also one student suggested the first meeting before starting one-to-one support should be offered online to "*get people ready to go*". The additional comment was just wanting a booking system in place in general.

Less suggested, but still mentioned by more than one student, was the want for more group work, and advertising issues. Three students wanted more opportunity for group work, specifically study groups. One student alluded to these being offered in the past and that they wanted them back, "*study groups again!*". Advertising concerns arose in two answers, both of whom were unaware of some or all of what services were offered by their institution, leading to one stating clearer advertising was necessary. As these answers came from users of MSS, and the most common reason for non-engagers was lack of awareness due to advertising issues, this again emphasises the need to improve advertising.

Remaining answers fell into the 'other' category, each only mentioned once (3.13%). These included, an anonymous question and answer forum, dislike for the changes to their support centre that had occurred recently, and one student wanting "*professors' realization of ours'* [sic] *not caring about the subject and only wanting to pass exams whatever way possible*". Although that last response came from a student who stated they had used both types of support, it supports other students' claims that some students do not want to put the effort in to utilise MSS to improve their ability and would just rather pass.

The questionnaires ended with the opportunity for respondents to provide any additional comments on MSS at their institution. Once unrelated comments and blank entries were removed, there were 44 total comments. Praise for the service they had experienced was given in 81.8% of comments. "*Very good I'll miss it when I'm gone !!*", "*I wouldn't have gotten this far without the MSC, I don't even know if I'd be passing. It is possible the best resource in the college*", and "*Maths support is an invaluable resource and has been a great help to me*" are a few examples.

The remainder of comments tended to reiterate something they had said previously in the questionnaire, particularly improvements. Seven comments repeated improvements discussed in the previous question, namely specialist help, online asynchronous resources, and change of mode. "*I have found it to be helpful generally at a lower level, harder levels maths or statistics was generally harder to find support on even from the academics that were supposed to specialise in the relevant areas*[.] *in first year the service was excellent and I got a lot of help but through the later years it became less useful*". Five comments reiterated advertising issues, either being unaware of the service or stating that there needed to be more. "*Just needs to be promoted more alongside saying it's okay to not understand at first and that's why the service is here*". The final two comments stated that they did not use support, and that students needed to be really motived to use MSS. "*…I feel like the student has to be really interested (or needed) in order for him or her to access these resources*".

5.4.2   Focus Groups and Interviews

The focus groups and interviews consisted of a total of 10 student participants, four from Coventry University in the UK, and the other six from universities in Ireland, namely Maynooth University, University College Dublin, and the University of Limerick. The students consisted of four regular undergraduates, five mature undergraduates (three of which stated they were on an access course), and one PhD student. To reiterate what subjects they studied, for the regular undergraduates: Mathematics, Motor Sport Engineering, Applied Maths (Theoretical Physics) and Applied Maths (Experimental and Mathematical Physics). The five mature students studied Computer Science, Science with Education (Computer science and Maths), an access course to Science, Agriculture, Medicine and Engineering, a mature student access certificate (Humanities) and Engineering. Finally, the PhD candidate had a research topic in Global Learning. All participants had used at least one form of MSS. The following two subsections detail the results of the question-by-question summary and the general inductive analysis giving an overall look.

5.4.2.1   *Summary of answers to interview questions*

This section provides a summary of the key ideas shared by the participants for each main discussion question that was asked.

<u>Warm up activity:</u> *How do you feel about Mathematics and Statistics support?*

Figure 5.10 Word cloud generated from Coventry University students' answers when asked to summarise how they felt about Mathematics and Statistics Support (Created using https://answergarden.ch/ 16.02.22)

The Coventry focus group was the only instance where the warmup game was applicable to play and so Figure 5.10 displays the results of that. Students were asked to enter as many words or phrases as they liked, to describe what they felt about MSS. It is important to note the interviewer also took part with the participants in order to break the ice, and their responses are depicted in blue in the Figure. All of the words and phrases in the smallest font were only entered once. The word '*helpful*' was the only

entry to be mentioned more frequently. The majority of entries offer physical aspects of MSS, such as project support and data analysis, with a handful that are more of the benefits, such as '*takes anxiety away*' and '*highers* [sic] *the chance not to fail*'. The most intriguing entry however was '*queue*', and when questioned on it, the participant, who also worked in the **sigma** centre at Coventry, revealed that he associated queue because some students got put off from using support that day because of the length of the queue.

Discussion Question 1: *What do you think maths/stats support is? How do you think it works?*

The key point put across from responses to this question was how different MSS is to lectures. MSS offers a one-to-one setting of sitting down with a practitioner and going over lectures or pre-assignment material that was found difficult. Material is discussed at a slower pace often with more reasoning behind using particular methods. This offered students a different experience from learning material in a lecture, and therefore was regarded as more useful. Some also commented on the mental benefits of MSS, how the service is always there when you need it, to build confidence and give reassurance, "*It was just people there to help*".

However, two participants also brought up their experience of two common fears / misconceptions that MSS often faces. One student thought they were going to be deemed as stupid due to having a low mathematical ability, "*I thought I would at the start like 'Oh, God they're going to think I'm simple, because my maths level was so bad'*". The other thinking that MSS was only for people who are struggling, "*naturally we all think it's support only when you're struggling, but I think sort of for me, I suppose that was what I initially sort of thought*". These two issues were selected by a number of non-engagers during the questionnaire.

Discussion Question 2: *Some students felt in-person support is 'easier' than online support. What do you think about this statement?*

Six of the 10 participants agreed with the idea that MSS is easier in-person. The general shared reasoning was having the ability to see and share work more easily, particularly for mathematics and the issue of writing equations online. Sitting directly next to someone allowed more easily for struggles to be spotted and supported, "*can't slide over your notebook and show them what you're working on and say 'where am I going wrong there?'*". Additionally, students made the point of it being easier to ask questions in an in-person setting, highly mentioned in responses to the questionnaire, as you are not having to interrupt everyone present like in an online call. They explained that in-person support also offers a more casual setting where you can sit and work at your own pace and ask for help if required, whereas online was often restricted to a meeting time and only certain content could be covered. However, gratitude was shown for the online support allowing access during the COVID-19 pandemic.

The other participants either disagreed or had mixed feelings on this. Online support was described as being a quieter environment that could be accessed without having to travel, and of particular benefit, allowed for a recording of the session to revisit in the future.

This question also illuminated the participants' preferences for online or in-person support without having to directly ask them; their opinions shone through without them having to explicitly say it, although half still did share their opinion. Of those that stated their preference, two preferred in-person while three favoured online. The remaining five's opinion could be deciphered through their responses, with four showing a preference for in-person and one stating they had mixed opinion but had only accessed online support. So overall, an in-person preference (6/10) was double that of the preference for online (3/10).

Many ideas discussed during this question reflected those brought up in responses to the questionnaire.

Discussion Question 3: *Maths and stats support is only a place for maths students. Why do you think people may have this view? (How do you think we could fix this issue?)*

There were some mixed opinions in the response to this question, however the majority did feel that they were always under the impression that MSS was for everyone. Some spoke quite highly of how they were clearly told that MSS is for everyone, yet they did also express uncertainty if other courses had experienced the same. One engineering student explained they were only told in their mathematics specific module, and not others.

Although speaking passionately about this topic, one student did explicitly admit "*there is kind of an impression that it's for just maths students*", and there were a couple of participants who shared an instance that also may have left them feeling this way. One was when staff were not able to help the student due to computer science mathematics being quite different, and the other was an engineer's in-person MSS experience, "*...[going to MSS was] more daunting because you'd be, the tutors... I think they were PhD students in maths. So, I was going in as an engineer and kind of felt 'should I know this?', 'Shouldn't I know this?'*".

Generally, when asked how to spread the message to students that MSS is for everyone, participants suggested an increase or improvement in advertising, even in the instance that they felt what was already in place was great, with one student stating they needed "*…just more of the same*". In particular, word of mouth from MSS practitioners and academic staff. "*Maybe tutors can mention it because they don't mention this. But when the two hours are up, you know, they just, pick their stuff and 'bye see you next week'. You know, they're too busy and have extra time*". This included collaborating with faculties, discovering and then targeting courses with elements of mathematics, statistics, and research, not only first years, but later years as well, as emphasised by one participant. This is very reflective of student opinion found in the questionnaire.

Additionally, two applied mathematics students expressed great appreciation for pre-assignment tutorial sheets provided to them in lectures. They explained it made MSS more accessible because they had something to identify their areas of concern, and take and work through with a tutor, that was not assessment content. This may also be a possibility to bridge the specialist knowledge gap that some Coventry University students brought up in their initial responses in the questionnaire, without hiring an endless number of staff with subject specific knowledge. Discussed more in Chapter 7.

Discussion Question 4*: What do you think is the most effective way to advertise maths/stats support to students?*

As potential solutions to the previous topic of discussion were all about advertising, it led nicely onto the discussion topic of what the students felt were the most effective advertising methods.

Visual advertising was probably the most commonly suggested idea, most frequently, posters around the physical centre (if applicable) or in areas of high footfall such as the library. The latter could be a workaround for institutions that do not have a physical centre and therefore lack that level of recruitment that comes from footfall, a concern brought up by practitioners in Phase 1. This will be discussed more in Chapter 7. Posters directing students were also suggested; signs such as bright arrows or cartoons could act as a visual guide to where MSS is based, as a few students expressed difficulty in finding the centre their first time, with one warning that students may not come if they are even too scared just to ask where it is. This idea was also suggested by students in the questionnaire.

For advertising online, flashing messages, pinned posts, and increasing social media presence were put forward as an online equivalent of visual advertising. Leaflets and QR codes were also suggested to increase reach, where a suggestion of making the institution's website mobile friendly, could work hand in hand.

Once again, many students brought up MSS staff and lecturers advertising support services in lectures, with one participant accounting "*I was in there all the time because he* [MSS practitioner] *told us about it*." But this also closely linked to other in-person advertising ideas, such as bringing students to the centre. This could occur during freshers' week or open days, which a few suggested were times a push in advertising was needed, and demonstrating in-person how the process works: "*familiarising the students with the tutors and letting them see that there's nothing to be worried about*". This idea was also proposed by four students in the questionnaire, both as an advertising improvement and as what would encourage them to use the other mode of support than the one they had accessed.

In opposition to this however, and as an interesting aside, one student mentioned that although his institution's MSS was advertised in lectures, he was the only one to go. He pondered that students may not be wanting or needing to go to support due to the influence of the pandemic bringing courses online, in part or full, and having open book exams, where students can use their notes throughout.

In support of a comment made in the previous question, two students also expressed the need for advertising to all academic years, not just targeting first year students. "*I think it's especially important the first year, because there's a lot of income* [of new students]*, but from the second and in the third year and I really think all students should be aware of these services that are offered*". One student even recounted his own experience of not needing MSS in first year but then left '*scrambling to find them*' after. Furthermore, it was also brought up by students in the questionnaire with one saying *"...it's hard to say you don't know what you're doing after a couple of years*", showing later years also need that additional help.

As an area of concern for the practitioners of MSS in the first phase of this PhD study was email overload, participants were asked as an additional prompt if overload was a concern for them, and how they felt about emails as an advertising method. Prior to this only two of the participants brought up emails as a good way of advertising; the way to reach the masses the fastest. However, the overall consensus was that emails are just 'fine', and students agreed that overload can happen or that students may just not read them. This was interesting as emails were a relatively popular suggestion for improvements of advertising online support by students in the questionnaire. In one interview a student did however praise how their university handled email overload, only targeting strategic times of the year for advertisements such as upcoming breaks.

Discussion Question 5: *Students feel nervous or embarrassed to access support. What do you think we could do to help these students? (Do you think this is the main reason why students do not engage with maths/stats support? Are there any reasons that just apply to in-person and any that just apply to online?)*

Three participants, all mature students, made an interesting observation that younger students tend to be the more fearful, and therefore, dismissive of attending MSS, coining it as generational psychology. One detailed her experience in that her younger peers would ask her to attend and then report back to them what she was taught. Another pointed out his experience of his lecturers being excited to teach mature students, as younger students do not like to talk.

More insight was also given into specific fears related to accessing MSS including, fear of finding a problem hard that no one else does, not feeling like it is a place for all abilities and therefore being judged, and finally the fear of asking stupid questions.

The most frequently suggested answer for other main reasons why students may not be engaging with MSS was time constraints, often having lectures conflict with time slots that support is on offer for. A popular opinion from respondents to the questionnaire as well. However, one participant made the interesting prediction that even if support was offered for longer, people would still end up challenged to find the time to go. Additionally, one student brought up the language barrier as another motivation

for someone not seeking support, as he himself did not speak English as his first language. He explained from experience that students cannot ask a question if they do not know the words to ask it.

Attending MSS in groups was regularly mentioned by participants during this discussion topic; both brought up as a suggestion that a lack of friends to attend MSS with can influence students not to engage, and as a solution to help students feel less fearful of accessing the service. MSS was praised by many for providing the opportunity to meet people who were also struggling and forming friendships, and therefore making attending support easier. This could potentially be an explanation of why group study was rarely chosen as a usage of MSS in the questionnaire. As the most common year group to respond to the questionnaire was first years, they may not have felt that they had fiends to attend MSS with, and therefore did not use it for group study.

Accessibility was regarded as the main barrier to in-person support, particularly for students living off campus, as they do not have the ease of just popping in because they were nearby, and so requires being more proactive. This is reflective of student's opinion in the questionnaire. A few also stated that online support is more appealing to people who are shy, as it offers a more relaxed atmosphere and the barrier of a screen. Conversely, the main barrier to online was the difficulty with asking questions and everyone being able to hear what you have to say.

Finally, participants were asked how we could help these students in attending MSS, and the general idea was that "*it just comes back down to advertising doesn't it*". Once again, the idea was that these students need to clearly have these misconceptions put to rest by reassurance from MSS staff or older students. *"It needs to be made clear, that anybody who is feeling like they're falling behind, it's not a big deal for them to ask for help", "maybe the tutors to say something about, there's absolutely no need to be embarrassed and we've heard it all before… there's nothing to be ashamed of", "somebody needs to tell them that, you know, don't be afraid, nobody will judge you".*

5.4.2.2. *Underlying themes*

Eight final themes were produced as a result of the general inductive analysis on the interview and focus group transcripts. Table 5.16 displays the number of mentions each overarching theme has, and the percentage of participants who mentioned them. All but the final theme could be broken down further into subgroups, providing additional information, and these will now be described in detail with supporting evidence from the transcripts. Any overlap identified between the author's and the independent coder's analysis is mentioned under the associated themes.

Theme	Frequency	
	Mentions	Participants (%)
Advertising	39	100%
Barriers to engagement	21	100%
Negative preconceptions	26	90%
Offering more than mathematics and statistics help	29	70%
Accessibility of online	10	70%
Praise for MSS	13	60%
Negativity towards mathematics	16	50%
Student Initiative	7	40%

Table 5.16 The frequency of mentions and the percentage proportion of participants who raised each underlying theme identified in the student focus groups and interviews

Advertising

The most frequently mentioned theme throughout the interviews, both in terms of how many of the participants brought it up and the number of times it was mentioned, was advertising. This was also the largest theme identified by the independent coder. Both the author and the independent coder recognised that this theme contained both suggestions about improving advertising, particularly creating more mindful advertising, and mentions of having a particular method of advertising already in place. Although this theme was a topic of discussion in the interview, its three subcategories, in-person, constant visuals, and social media, were mentioned frequently enough throughout the interviews that advertising became a theme in its own right.

In-person advertising was commented on by 100% of participants and was the most highly mentioned subcategory. The most popular suggestion or experience shared was having both lecturers and support staff advertising the support services in lectures. As explained under the associated question, many emphasised that it was an effective method or was what got them to use MSS: "*sometimes when somebody has kind of gone in, a student would always remember that*". One student described how meeting the support staff before helped make the initial accessing of support less daunting, "*if they already have a face, a familiar face, it could be easier to go in*".

The idea of needing more constant or repetitive visual advertising was also suggested by seven of the 10 participants: more fixed repetitive reminders such as posters, top-pinned posts online or regular informing by staff. One student even compared advertising of their institution's maths support to that of another service, claiming it was more well known than MSS due to this reason: "*...maybe know about the math learning centre, they know about writing centre because they've been reminded constantly*".

This supports that the most common suggestion for advertising improvements in the questionnaire was more frequent advertising.

Finally increasing activity and being present on social media also received a few mentions.

Barriers to engagement

The only other theme to receive 100% of participants mentioning it was barriers to engagement that the participants had had to overcome when they accessed MSS. This theme was also identified by the independent coder when two of their themes were combined together, namely 'face to face is better' and 'reasons for non-engagement'.

Information coded into this theme was either a comparison of online to in-person, or timing hurdles preventing engagement with services. "W*hen you have to choose, you know, go to the maths learning centre or go to lecture, it's not good choice I would say*". The disadvantages to online support mentioned included: difficulties in sharing work, particularly when having to input equations on a computer; problems asking questions in an online setting, such as everyone hearing your question or having to strategically find an opportunity to jump in and ask; harder to spot issues online compared to in-person, such as when mistakes are made, or the student is not understanding; and finally technical difficulties.

Negative pre-conceptions

MSS has repeatedly faced a number of pre-conceptions from students, resulting in a lack of engagement. Examples include a fear of looking stupid; thinking they will be judged for their (lack of) mathematical ability; being embarrassed to access support; and that MSS is not for all abilities so they cannot ask what they need to for fear of it being 'too simple' (Grehan et al., 2011). All of these pre-conceptions listed here appeared in this theme, whether the students expressed feeling it themselves, "*I did feel that myself at the start, where you feel a bit kind of stupid that, you know, you don't know something*", or suggested other students may be feeling that way, "*maybe they feel kind of, you know, I don't know, judged or whatever*". General statements about students feeling afraid or embarrassed to access support, and the fear of appearing stupid, were the two most commonly mentioned subgroups, with nine and eight mentions respectively by six and four participants in total. All of these were also present in responses in the questionnaires.

Embarrassment was one of two sub-themes identified by the independent coder, under the umbrella 'online is better', particularly in relation to age and younger people being more embarrassed.

Offering more than mathematics and statistics help

The theme of 'offering more than mathematics and statistics help' contained any mention of MSS having other positives to offer besides direct support in mathematics and statistics. This theme can be split up into three subgroups: social aspect, workspace, and mental benefits.

The social aspect of MSS was mentioned the most within this category: 15 times by four students. It contained mentions of getting to know people through MSS, often making it easier to go and seek help. "*It was just so nice to have that little community where we could go to*". Praise was given to the opportunity an MSS centre provides to work together and help each other out on problems, especially when the tutor was not available.

This closely links to another subgroup: workspace. For institutions that have the ability to have a physical MSS centre, it provides that additional space to sit and work. Even if help is not required, a student can sit and work through content in their own time with the comfort that help is nearby if and when it is needed. This exact sentiment was also brought up in the questionnaire. Workspace was also identified as a small theme by the independent coder.

Finally, mental benefits included any mental aspect that using MSS can improve, such as mental health, confidence, and reassurance, with one student revealing how MSS building his confidence was "*more important to me than the maths support itself*". This theme really reveals the hidden values that MSS can provide.

Accessibility of online

This theme is almost the opposite of the 'barriers to engagement' theme in that it contains benefits to online learning as provided by the students, mentioned by 70% of the participants a total of 10 times. This was the other larger subtheme of the 'online is better' theme identified by the independent coder.

Just over half the responses described the benefit of not having to travel to campus for online support, particularly for students who live away from campus, still allowing them to access support when they needed it. In support of this, one student explained that as she did not live on campus in her first year it was harder for her to start going to MSS. It is important to note that as she was a final year student at the time of data collection, she would have only had access to in-person support in her first year. Additionally, just under half (4) of the interview statements coded into this theme discussed the anonymity of online, and how not needing to have your camera on creates a different atmosphere often beneficial for shy individuals. Comparatively, in the student questionnaire responses, anonymity of online support was only mentioned by one student on one occasion.

Praise for MSS

Potentially the most positive theme to be generated from the interviews, 'praise for MSS' contains any comments praising a students' personal experience using their institution's MSS, and really highlights the personal value and gratitude engagers with MSS feel. "*I'm actually devastated to be leaving because of the maths support service", "It's a fantastic resource. I just I'd be lost without it*". Additionally, this category also contains positive comments towards MSS staff, specifically their personability, with students addressing how nice their experience was and the ease of talking to the practitioners with how willing and enthusiastic they were to help. The independent coder identified examples of rapport and body language under their 'in-person is better' theme, which ties into this theme.

Negativity towards Mathematics

Half the participants mentioned some form of negative opinion of, or experience with, mathematics; 16 times collectively. The four students who made a claim that they were not good at maths took up 10 of these, with one participant stating this about himself on four separate occasions. These statements were general professions that they felt they did not have an ability in one or all areas of mathematics, with two students giving examples of failure in the past. Two students expressed that mathematics gives them anxiety, with an additional student stating that having access to online MSS prevented her anxiety because without it she would not have known what to do and been "*stressed and anxious*". Additionally, one of those students also expressed twice that they had no self-confidence when it came to mathematics, "*I still found it like, extremely difficult because my confidence was so low. I just felt I couldn't do it* [mathematics]". Finally, one student made a general statement claiming, "*some students just do not like mathematics*". This theme was not as obviously identified by the independent coder, however a dislike for mathematics was included under their 'reasons for non-engagement' theme.

Student Initiative

The final category, mentioned by the least number of participants, contains statements about students having to use their own will or initiative to know when they are struggling and then find and access the support services they have on offer. "*I feel like it's a lot of personal will really, to make you go in the first place*". Although this theme only had a small number of statements from the participants coded into it, and was not picked up by the independent coder, it holds an interesting comparison to the practitioner perspective in Phase 1. This comparison was also mentioned when reporting that motivation came up in the questionnaires as a theme of answers to why students were not engaging with MSS, and is elaborated on in Section 5.5.

5.5   Discussion

To reiterate, one aim of this phase of exploration was to investigate student opinion of MSS provision and its effectiveness since the pandemic (RQ3).

This exploration has shown that there is a clear preference for in-person support, regardless of usage. This preference was even shown by some of those who have only used online support indicated by 'it was the only option' being the second most common reason for engagement with online support, after just needing help. This is supported by Mullen et al. (2021, 2023) but contradicted by Smith (2022) in terms of MSS, but reflects opinion found for online learning in general all over the world (see for example, Banks & Vergez, 2022 [USA], Nishimwe et al., 2022 [Rwanda], Neves & Stephenson, 2023 [UK]). However, an important finding is that there were still some students who preferred online support (also found in Mullen et al., 2023), and the accessibility and flexibility that online support provides is held in high regard, even if their preference was for in-person. This mirrors the opinion of practitioners found in the previous phase of exploration of this PhD study, where in-person support was preferred, but availability and flexibility were the most commonly identified advantages of online support. Student groups mentioned to have benefited the most were distance students, who struggle to get to campus, and mature students, who have busy life schedules; two student groups who were also mentioned as main beneficiaries by practitioners in Phase 1.

A common theme that came up throughout the questionnaire was communication and learning experience, in-person fostering an environment that made it easier to understand and learn, which had a clear influence on a student's preference of setting. Learning effectiveness was also a theme of advantages for in-person learning and disadvantages of online learning stated by students in Dinh & Nguyen (2023). In particular, many students felt that it was far easier to ask questions in an in-person environment which therefore aided their learning and understanding. Students who were interviewed also stated this was the case. This is in contradiction to Hollister et al. (2022) who found the opposite when surveying undergraduate students on their experience of online learning during the pandemic. They proposed that this may be due to social barriers, and that students who would not usually have been confident to ask a question in-person can do so using a chat function without disrupting focus of the session. Although it is important to note this was in an online lecture setting with multiple students rather than a one-to-one dynamic. This has been reported to benefit anxious students (Yep et al., 2023). However, in this phase of the study, anonymity of online, confidence or anxiety were rarely mentioned if at all. Instead, communication was highly valued, and therefore getting their point across, particularly with the difficulty of communicating mathematics in a virtual setting, may be more important to these students than confidence of asking the question in the first place. However, this may have been a case of how the interview participants were sampled, as the students in this sample are likely to possess more confidence given they put themselves forward voluntarily.

In Phase 1 of this research study, the loss of opportunity for students to work collaboratively in groups, and the difficulty faced in facilitating that, was a frequently mentioned concern of the practitioners. This included reference to how students value the social side of MSS and university life in general. In 2020, Mac an Bhaird et al. (2021) set up online study groups to supplement drop-in MSS service at Maynooth University, and they reported that students really valued the opportunity to interact with peers again rather than "*watching some recorded lecture alone in your room*" (p.362). Responses discussed during this phase of exploration do show students' value of social interaction and group work. The ability to work in the support centre with peers, surrounded by help if required, was repeatedly praised. However, it was interesting to see that other positives or negatives of the different modes of support were mentioned a lot more frequently. This was also seen in Mullen et al. (2023) who found that regardless of usage type, interacting with peers was of lower importance, which contradicted their previous study, Mullen et al. (2022). This might be evidence that the impact of the pandemic is beginning to fade. Social interaction and collaboration may have been highly sought after once a return to 'normal' allowed such interactions to happen again, because they had been prohibited to during the height of the pandemic. Now that students are once again back on campus, with many institutions adopting a blended approach, interacting with peers in MSS may not be as much of a priority anymore.

Another aspect explored was whether there is a difference in students' opinion based on the form of MSS they had used. Students who had used both forms of support were shown to be more critical of student attitudes than the MSS provision, feeling that they needed more motivation to engage and learn online; an idea also reported in Armstrong et al. (2021). This was supported by the 'Student Initiative' theme, which although only mentioned seven times, was still included as a theme as it also shares an idea with the 'Effort' theme generated in the practitioner interviews. Practitioners felt that one of the areas requiring more effort was related to students actively approaching and using the service, where one participant stated that effort was required from both sides to make MSS a success. It seems that there are some students who also agree with this idea, that students must also meet practitioners halfway.

Additionally, current barriers to students' engagement were also explored for the purpose of discovering ways to reduce them, addressing RQ4.

The most common reason, after not needing support, was 'being unaware', identified both by non-engagers themselves, and students who had utilised support. Having never heard of support services, not knowing where to find them, not knowing what to expect, or being unaware of the benefits were all mentioned or selected as factors, all of which could be addressed by advertising. This was echoed by the themes generated in the interviews, where advertising concerns, particularly the need for communication in lectures, was mentioned most frequently. Symonds et al (2008) found a similar result from interviewing STEM students who were non-engagers with MSS at Loughborough University. The greatest number of students expressed a lack of awareness of the centre's location as being their reason

for not engaging, followed by not knowing of the facilities on offer. This is reflective of O'Sullivan et al. (2014) who found a significant number of responses stated improving advertising, particularly the promotion of the location of the service, would help them to engage. Mac an Bhaird et al. (2020b) also found the majority of responses explaining why they had not engaged with online resources was not knowing they existed.

Symonds et al (2009) hypothesized that this finding was a result of students giving procedural reasons for non-engagement to hide their real affective reasons. This could be reflected in 'not having gotten around to it' being the second most common reason given by non-users for their non-engagement, after manipulation of the data. However, in contrast, in this exploration embarrassment was the joint second most selected reason, and fourth overall after manipulation, as to why non-engagers said they did not engage with MSS. Additionally dislike and fear of mathematics were chosen in combination third most commonly after manipulation. These reasons are in the affective domain, as it is an action guided by emotion rather than practical or procedural reasons, such as not knowing where support services are located. This contrast could simply be because advertising of MSS services has improved since this data collection took place, and therefore more students are aware of what is on offer to them. As these procedural reasons were reported as being the most influential factors for non-engagement, it makes sense advertising efforts would have to be focused on these areas. Potentially now, with these improvements having been made, and all the heightened emotions and trials that came with the pandemic, students are now more willing to admit deeper reasons for not engaging. It is an encouraging finding as a shift in the focus of promotion of services can now occur to address these more emotional reasons. However, to verify this, future exploration into the student opinion of MSS and reasons for non-engagement needs conducting for comparison.

The overall takeaway from this phase of this PhD study is that students would like more advertising, but more specifically, more thorough, and thoughtful advertising. "*If the service was not only promoted, but promoted it was okay to not understand*". However, although traditional methods of advertising such as emails, posters and social media were mentioned in suggested improvements, it has commonly been found that students do not read emails, do not notice posters, and do not interact with social media. So, it creates the question of how we achieve this, and this will be discussed in Chapter 7.

5.4.1   Limitations

This section considers three limitations found during this phase of the study.

Similarly to the practitioner exploration phase, participants were limited to students at institutions with a practitioner registered on the **sigma** Network Jiscmail list, due to recruitment via gatekeepers.

Two participants in the student focus group were student proctors for the **sigma** centre at Coventry University, meaning that, as well as using the centre for support for themselves, they are also employed

by the centre to support students. Therefore, they have a wider knowledge of MSS and as a result their views may not be typical of other students; having a view of what support practitioners would like all students to view support as, rather than how they would feel about the support as students. Therefore, their answers are not as generalisable as those of other students. However, having that greater knowledge could result in these students identifying valuable information that other students cannot see.

Due to lack of volunteers through the questionnaire for the follow up focus groups, and having to ask gatekeepers to assist with recruitment, participants in all the focus groups / interviews were students who had used MSS. This meant a more detailed perspective from someone who had not used MSS was lacking. However, non-users of MSS were the second largest group of participants to answer the questionnaire, and therefore still have made significant contribution to the data collected.

5.5   Summary

This chapter detailed the second phase of a three-phase investigation exploring mathematics and statistics support in the 'new normal'; an exploration into the student perspective. A questionnaire with follow up interviews and focus groups were used in a mixed-methods approach to explore student opinion as of the academic year 2021/22. The data collected from two investigations were combined and analysed for a look at the student perspective as a whole. Students shared similarities in their opinion of MSS with that of MSS practitioners, particularly about the level of effort required to use support. There is a large emphasis on learning environment, and as a result a clear preference for in-person support by students. However, there are still some who regularly utilise both and a small number who even prefer online support, most commonly due to availability and flexibility. However, the key conclusion was that advertising needs improving on a deeper level, not just marketing what is on offer, but how and why it can be used.

6 Exploration of the pedagogy of in-person versus online support

The third and final phase of this PhD study explored the pedagogical practices of in-person and online support provision. An observational study was conducted at three UK universities to observe how MSS tutors supported students in both settings with a view to making a comparison. General observations of a Mathematics and Statistics Support Centre were also conducted.

This chapter begins with a discussion of why pedagogy was explored, linking back to evidence found within this PhD study so far. The research question associated with this phase is also re-addressed. The specific data collection process, namely design, method, and sample, for each observation type is then detailed in Section 6.2, including the supporting literature used in this design process, and 6.3. This is followed by detailing the analysis that was performed on the observational data collected, as well as the information provided by participants in the post-observation conversations that were held during tutor observations (Section 6.4). Section 6.5 and 6.6 describes the subsequent key findings, before following up with a discussion of this phase in Section 6.7, where any identified limitations to the study are also reflected upon. A final summary of this chapter is provided in Section 6.8.

6.1 The approach

An important finding from Hodds (2020a), a key study mentioned throughout this thesis, was that practitioners did not feel comfortable or trained enough to provide online support to a *'standard that would be comparable'* to the in-person support they were providing pre-pandemic (Hodds, 2020a, p.6). 'Training and Knowledge' was also an identified underlying theme in the 12 interviews that were conducted in the early months of 2021 during Phase 1 of this PhD study. Staff were concerned about the pedagogical practices of online teaching and learning. They expressed that students needed to be supported in adapting their study skills to the new online setting and therefore staff needed to be taught how to best aid them in learning this. Mullen et al., (2022) also state that "*it is clear that online MSS requires a different set of pedagogical and technological skills*" (p.82). This suggests that practitioners feel that the pedagogy involved supporting students in an online setting, is different to that in-person.

Corroborating this, the Office for Students report reviewing practice of online teaching a year into the pandemic, used as a key source in the literature review in Section 2.4, stated that "*For digital teaching and learning to be effective, it must start with pedagogy"* (Barber et al., 2021, p.19). This view means that adapting to online learning should not be a matter of just simply adding technology to attempts of replicating traditional teaching methods in this new setting. The report indicates that new methods needed to be designed with a focus on how students learn, to help them adapt to the new environment. Finally, as presented in Chapter 5, there were a handful of responses to questions across the student questionnaire illuminating that learning and pedagogy might be different in an online setting. These

responses particularly related to the difficulty learning in an online setting presents. Out of 54 students who had used both forms of support, 77.8% stated that they preferred in-person provision. When asked to explain why, a third of responses related to in-person support being a better learning experience. "*Way too hard to understand or interact online*", "*I find it easier to learn when I am physically with the person who is teaching me*". Additionally, this sentiment appeared in response to other questions, such as when asked about advantages and disadvantages of online support. Being a better learning experience was also the most frequently mentioned advantage for in-person support, and likewise for disadvantages for online support. "*A lot less clear and more difficult to understand*", "*…more chance for misunderstanding…*".

As concluded in the two preceding chapters, although in-person provision is still favoured, the value of online provision is now more recognised by practitioners and some students. Thirteen months post-pandemic, practitioners stated they wanted online support to remain in some capacity alongside the return of in-person support. For students, online support was actually preferred by a small number, and the reasons why, as well as the most common advantages provided, were related to accessibility and convenience. Hence if online provision is to continue, and with evidence pedagogy may differ between the two settings, it is important to consider underlying pedagogy to ensure online teaching is as effective as can be.

Therefore, this final phase addresses research question RQ5: Is there a significant difference in pedagogy based on whether MSS is delivered online or in-person and what influence, if any, does this have on students?

Observation with a follow up private discussion was the approach chosen for this exploration. MSS practitioners at three UK universities were observed supporting students in both online and in-person settings for a comparison. Although the tutors were the main focus of the study, how students responded to the practitioner was also observed. This was important to include so that it helped answer the latter part of RQ5. As described in Section 5.1, it has been speculated that students are not always honest with their answers when asked in a survey or interview. Therefore, observing behaviour from an outside view in a natural setting may offer a truer representation of their opinion of support provision. Follow up discussions were then held after each observation with both participants involved, so that what was observed could be compared to their voiced opinion.

As this was a comparative exploration, it was important that the same observation process could be repeated between participants, and the data collected could be compared. Therefore, a structured observation technique was used. This meant that confounding variables could be controlled where possible, and behaviours common to MSS practice could be pre-identified and then confirmed or counted if a participant displayed them during the session. As a result, quantitative data was produced

that could then be more easily compared between observations. Additionally at one university, general observations of the environment were conducted, measuring elements such as noise level, busyness, and student usage, to also explore what influence this may have on users of MSS.

Hence a systematic procedure was required, that could be followed in the running of the observations. This also included designing a checklist of pre-determined behaviours or elements to pay attention for or measure, necessary for both types of observation. These behaviours had to be measurable and quantifiable, namely could be represented as binary, frequency, or scale data. Details about the data collection for both types of observations are discussed in the following sections, namely the design, how the observations were executed and finally the sample observed.

6.2 Data Collection for Tutor Observations

This section describes the data collection process for the observations focused on tutors supporting students in a one-to-one setting both online and in-person.

6.2.1 Design

Protocol

As mentioned above, a pre-designed protocol was needed for the observer to be able to follow each time an observation was conducted. This detailed an overview of how to conduct each observation, from the recruitment process to the post-session discussion. The details for each of these areas are discussed in the method subsection 6.2.2, but the general structure was as follows:

Recruitment:	Details of how recruitment of both MSS practitioners and students was to happen, including how MSS tutors could be targeted to explore specific characteristics, for example, gender, age, and years of experience.
Introduction:	Presents the important information that should be given prior to the observation, specifically introductions, the purpose, a brief procedure, and that a private conversation will be held with the participants after the session has ended.
Observation:	A guide to how the observations should be carried out both in-person and online based on what level of observation the participants have given consent for: video recorded or observation only (with the additional option of audio recording for in-person observations).
Discussion:	Details of the private discussions to be held with both participants following the observations. Participants should feel they can speak freely and

confidently about the session. Brief demographic characteristics of the participants should be collected at this point.

| **Checklist:** | The pre-designed checklist of behaviours to identify during the observation and the form to be used to complete the follow up-discussion. |

Discussions

A mix of open and closed questions were pre-designed for both the practitioner and the student being supported; four and five questions respectively. Questions mainly focused on the session that took place, but with an additional broader question asked to each side, and a final additional comments question included to collect any extra information either party deemed important to say (see Appendix 6).

All participants were asked how they thought the session went, what they thought went well, and also what could be improved upon. Therefore, not only could opinions of the participants be compared to the observations the observer made, but also to each other. Additionally, students were asked if they felt that they had achieved what they came to the session for, again for a direct comparison to how the observer thought the student had responded to the session. Practitioners were also asked, based on their experience as a tutor, if they felt the students' behaviour had been influenced at all by being observed. This was put in place as an additional check for an observation bias.

One additional question was asked to participants about support in general. Students were asked if they would use that type of support again. This question was in place to gain a perspective on current student opinion of online versus in-person MSS a year on from the previous stage of this PhD study. Practitioners were asked how often they felt they did not have the subject knowledge to help a student. This was asked as a way to check tutors' current self-confidence levels and explore if their demographic characteristics had any influence on their answer.

Practitioners were asked their gender, years of experience and whether they were classed as a mathematics or statistics tutor, or both. These characteristics were chosen as they seemed they could have an influence on the use of pedagogy and the resultant response from students. Students were asked their gender, year of study, and discipline.

Checklist

In order to determine which behaviours should be included on the checklist, namely the most crucial behaviours for good practice of an MSS tutor and key behaviours a tutor should avoid, a range of literature exploring the practice of MSS was reviewed.

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The literature discussed here were chosen as they are the key works discussing best practice in MSS. They cover a range of locations, tutor type, and support method to ensure generalisability of behaviours. It is important to note that they are all based around in-person MSS (since they all pre-date the pandemic), and as online support is relatively new, good practice has not been explored in the literature. However, for all principles of practice identified, it should not matter what setting the provision is in, they should (or should not) be displayed regardless. Below is a brief summary of each of the papers, followed by a table detailing the key concepts of MSS practice that were identified in each.

Fitzmaurice et al. (2016) describes a tutor training programme delivered by the Irish Mathematics Learning Support Network (IMLSN) (the Irish collaborative cross-university network for MSS practitioners) in three universities in Ireland in 2015. They ran focus groups with fourteen of the tutors involved, to evaluate the programme and explore what impact it had on the tutors' teaching. The paper reports key themes generated from the focus group discussion.

A case study by Walsh (2017) explored the pedagogical skills of three post graduate mathematics support tutors, all of whom did not have backgrounds in mathematics education or research in pedagogy, running weekly hour-long support tutorials at the University of Limerick, Ireland. The first of these sessions of the semester were video recorded for analysis and discussion to explore the current state of tertiary tutoring at the time. This study focused more on behaviours displayed by the tutors that needed improvement and the advice given to improve their pedagogical methods.

Delderfield and McHattie (2018) also describe a case study, where four of a mathematics advisor's pre-booked one-to-one appointments at the University of Bradford were video recorded for analysis of her practice. The authors summarised a list of observations made by the reviewer before discussing the core elements in more detail.

Finally, Lawson et al. (2020) produced an extensive literature review detailing the evolution of MSS. Their review includes a section detailing the role of the tutor.

Each paper was read and key behaviours or principles, both for good and bad practice for tutors in MSS that the authors identified or discussed within their work, were listed for each source. These concepts could have been directly mentioned in the text or inferred through the authors' discussion and are detailed in the table below (Table 6.1).

	Fitzmaurice et al. (2016)	Walsh (2017)	Delderfield & McHattie (2018)	Lawson et al. (2020)
Personable	Demonstrating an understanding of the students' situation Remaining enthusiastic*		Fostering a calm and purposeful working environment* Use of their own non-verbal cues** Being welcoming Demonstrating an understanding of the students' situation Responding to students' unspoken cues Use of body language and eye contact	Being welcoming Build students' confidence Use of their own non-verbal cues**
Communication	Adaptable to different abilities Tutors do not have to know everything**	Clear writing Speed and clarity of talking and teaching Giving students time to answer** Using uncertain statements e.g., 'I think that is…'** Adaptable to different abilities Recapping what had been covered* Honesty when mistakes are made Allow students to ask questions* Asking higher order questions	Different methods of responses Honest but neutral correcting** Positive reinforcement for successes Using silence appropriately Honesty when mistakes are made Open questioning**	Adaptable to different abilities How to deal with something unknown** Patient** Neutral correcting Open questions**
Facilitated learning	Drawing knowledge from the student Explaining concepts rather than just telling the student how to do it Try and find the root of the problem Using students' notes to assist teaching*	Allow students to attempt their own questions and give them time to do so Checking for understanding Explaining concepts rather than just showing or telling the student Demonstrating multiple ways of approaching a problem Use examples / applications to aid explanation** Sequencing of sessions* Knowledge of resources*	Demonstrating multiple ways of approaching a problem	Try and find the root of the problem Drawing knowledge from the student Demonstrating multiple ways of approaching a problem
Negatives		Not using judgemental language: 'easy', 'simple', 'you should be able to do it' Don't make assumptions of students' knowledge Tutoring should not be didactical**	Not using judgemental language: 'easy', 'simple', 'you should be able to do it'	Being non-judgemental** Not using judgemental language: 'easy', 'simple', 'you should be able to do it'

Table 6.1 *Key concepts and behaviours discussed in the supporting literature used to design the checklist for structured observations. * Not included in the checklist ** Included in the checklist under an umbrella term*

An additional source was Ryals et al. (2019). They explored how undergraduate mathematics tutors identified and responded to learners who knew how to do something but did not know when to apply it. At a large public university in the US, eight peer drop-in tutors for the mathematics department were asked to video and audio record some of their written work when interacting with students in a one-to-one setting. Each tutor selected and reflected upon one short recording and subsequently had an interview with their supervisor, which were then analysed along with the recordings. This paper repeated two behaviours found in the other sources, namely responding to unspoken cues, and drawing knowledge from the student. Also, two additional behaviours that linked to others displayed in Table 6.1, 'Provide opportunity for the student to demonstrate how to approach a problem', linking to allowing a student to attempt their own question, and 'give students time to answer', linking to using silence appropriately.

These identified concepts then needed to be condensed into specific observable behaviours to be included on the checklist. There was some overlap in the identified concepts from the papers discussed, which helped to determine the most desired, or undesired, behaviours. Although, it was also important to consider unique behaviours identified as well.

Not all behaviours identified within the literature were chosen to be included on the checklist, however. These have been denoted by an asterisk (*) in the table. The two main reasons for making that decision was how applicable they would be to the type and setting of support that was being observed for this study, and how observable or measurable they could be. For instance, controlling the sequencing of sessions and recapping what had been covered are more appropriate for longer appointment-based support or tutorials where the sessions are pre-determined and cover a lot of material. An example of a behaviour that was deemed more challenging to measure was 'using student's notes to aid teaching'. This would not always be applicable in that a student may not have notes or they may not be needed, or the notes may not be of high quality which would negatively impact the tutor. Being aware of these behaviours however meant that if they did arise, they could be noted down in the additional comments section, which is elaborated on in a moment.

Some identified behaviours were similar in nature or examples of each other, and so could be combined under umbrella terms. These have been marked with a double asterisk (**). For example, giving time for students to answer questions can be an example of using silence appropriately, as can being patient. The largest case was for 'Tutors do not have to know everything', 'How to deal with something unknown' and 'Use of uncertain statements', which were all encompassed under honesty. These considerations were important to make as there was only a finite amount of space on the checklist, and overcrowding would reduce usability.

Having determined the content, the design of the checklist then needed to be considered. It was decided for the behaviour checklist to be one A4 size form, minimising having to scroll or turn over pages while completing an observation. This was to keep the checklist as simple to use as possible. It was segmented into three sections, positive behaviours, negative behaviours, and student response. Space for additional notes and details of the observation session was provided at the bottom. A second page was used for the follow-up discussion, detailing pre-set questions and space to transcribe the participants' answers, as well as an area to note participant characteristics (see Appendix 6).

The positive behaviours identified in the sources discussed were grouped into three key areas for the means of organisation and ease of use. These were:

- **Personable**: The tutor's manner and response to the learner; being approachable, using body language, seeking an understanding then responding accordingly, and building the student's confidence.
- **Communication**: How the tutor converses with the learner; being clear, confident, and honest, and adapting to the student with appropriate questioning and response.
- **Facilitating learning**: The use of pedagogical methods to encourage deeper learning; discovering the root problem, explaining processes while drawing information out of the student, allowing time for solo attempts, all while checking for understanding.

Negative behaviours were those that can decrease students' confidence and understanding (for example, assuming the student possesses knowledge they do not or implying the problem faced is easy), and impersonal behaviours that can make the session feel uncomfortable (minimal eye contact, talking too fast and pressurising the student).

As mentioned in the previous section, although tutor behaviour was the main focus of the observations, it was important to also record how the student was reacting, in terms of their response behaviour. Four, five-point Likert scales were used to record the student's confidence level at the beginning and end of the session, overall comfort, and engagement. Five-points were used to mirror what had been used in the previous phases of this PhD study. Using scales to represent these provided more information than simply asking yes or no questions and can account for changes throughout the session. Space to record body language and whether the student seemed satisfied at the end of the session was also included.

As explained, the checklist was designed so that quantitative data could be collected. There was space left after each behaviour for the observer to tick or tally mark, where applicable, if that behaviour had been displayed. This then generated binary or frequency data. Whether a behaviour being present was to be answered as a 'yes or no', or counted for how many times it was displayed, was determined by whether it could be displayed multiple times on separate occasions, sometimes in different ways, or whether it just occurs generally. For example, having clear writing is a general behaviour, whereas using higher order questioning is a behaviour that could be demonstrated multiple times, or alternatively

not demonstrated at all. Some behaviours, such as 'good use of body language', could arguably be either and were therefore determined after completing the first observation based on experience of what felt most natural.

In addition, two of the (video-recorded) observations were coded independently by another researcher, and a discussion was then had about how they each individually completed the checklist. There was some overlap in how the observations were coded. It was deemed that some of the differences that had arisen were possibly due to the level of experience in MSS that both observers had (31 years compared to three), resulting in interpretation of some of the behaviours being different. Therefore, it was felt that the checklist could benefit from more explanation and examples on how these behaviours should be interpreted. Hence a second independent coder was then recruited and provided with a video explaining how to complete the checklist, with additional explanation of the behaviours. Again, when comparing the independent coder's checklist to that of the authors', overlap was found. There were some striking similarities such as the exact number of a long tally, or the same quotes / examples identified from the tutor as evidence. Overall, due to the subjective nature of observations, there is likely to be some level of influence of the observers' own interpretation on the observations made, even with structured ones. Hence, as a whole, as there was overlap between both the independent coders' completed checklists with the author's, it was deemed that the data discussed in this chapter is representative of what occurred in the sessions observed. However, this has been discussed as a limitation in Section 6.6.1, as it does open up opportunity to improve the observation design in the future to try and minimise the differences as much as possible.

Furthermore, an additional notes section was included for the ability to detail any unique behaviour the observer deemed important, or for noting examples of how the observed behaviour was displayed. This was included to allow for observations to not be fully constricted to the behaviours chosen for the checklist.

6.2.2   Method

Observations were conducted at Coventry University, The University of Northampton, and Loughborough University. As two of these institutions were external from where this PhD was based, the procedure slightly differed, but this will be explained when applicable.

Originally it was planned to only observe and compare drop-in support in the two external environments. However, due to uptake by students, and provision varying at all the institutions, appointment-based support was also observed. The main difference between the two provisions is that for appointment-based support, a tutor knows in advance when they will be supporting a student, and often may have an idea as to what area, and this may allow for some preparation. However, for the most part, pedagogical techniques should remain the same.

All participants took part in the study on a voluntary basis. MSS tutors were recruited from staff members employed at the institutions at the time the study was conducted. Participants were either core support staff (specialist staff employed for MSS), teaching staff (providing additional support outside of their teaching) and PhD students. Tutors at Coventry were briefed in-person, and then sent a follow up email with details of the study and a consent form to complete if they were willing to take part. For the external universities, one key practitioner was corresponded with by email. The same information was provided, which they would then pass on to their colleagues to see who else felt they could be involved. All tutor participants also had to provide consent to being observed and at what level, namely video recorded or just observed with the additional option of audio recorded for in-person observations.

Student participants were recruited from those present in the in-person or online drop-in centres on the days the observations took place, or from those who had pre-booked online or in-person appointments with a tutor. Student participants were approached initially as they entered the centre and spoken to, or prior to their appointment via email. Again, all participants had to give their consent to participate, and determine to what extent they felt comfortable being observed. Most commonly this was received verbally before the observation took place, and then written consent was achieved after.

During the introduction stage students were introduced properly to the observer who explained the purpose of the observation. They also received a brief overview of how it would be conducted where it was stressed that the main focus was on how the tutor was conducting the session, and in no way a judgement of the ability of the student or specificities of the content. This was to ensure the student felt comfortable and acted as naturally as they usually would. It was important to reassure them that the observation would not influence the support being provided, nor would it if they felt that they did not want to participate.

Observations were conducted differently depending on whether they were online or in-person, recorded or just observed.

For in-person recorded observations, a recording device, in this case a mobile phone, was set up on a tripod next to where the participants had chosen to sit. As far as was possible, the camera was set in a position that was out of direct eyeline of the participants. The observer would then start the recording and move away until the support session ended where they would then return to stop the recording. This was to try to keep the session feeling as natural as possible and to minimise the extent that being observed could influence participant behaviour, controlling for the Hawthorne effect (explained in Section 3.3.4). The checklist would then be completed retrospectively using the recording. For observation only, sessions that were not video recorded due to preference of either participant, the observer sat at a nearby location, again out of eyeline, and completed the checklist synchronously as support was being provided.

Online observations were collected over the software of choice used by the institutions. BigBlueButton or Microsoft Teams for Coventry University, and Microsoft Teams for The University of Northampton and Loughborough University. For recorded sessions, after the introduction had been delivered, the observer left the video conference, and the practitioner recorded the session and later shared it with the observer. Once the session had concluded the observer was contacted to return. For observation only, the observer would remain in the video conference but with their camera and microphone off. This was again to ensure the reduction of any observation biases. Due to data sharing restrictions, none of the online observations conducted at external universities were recorded.

As mentioned in Section 3.3.4, observations can be subject to an observer's own biases, and as a way to combat this, Johnson (1997) explained observers should practice critical reflection. This is where the researcher becomes more self-aware to monitor and control their biases. A way of achieving this was to be critical each time an addition was made to the checklist. This meant the observer would actively question themselves 'why' each time a behaviour was to be confirmed or counted and would only do so if a concrete example could be supplied in evidence if theoretically asked.

Where possible, practitioners were observed offering support both online and in-person for a comparison of their individual behaviour. Observations continued for as long as the student required assistance, for a minimum of five minutes. This minimum time was put in place to eliminate any short queries or time constrained support during busy periods. The checklist was always completed digitally.

Private discussions were held with both participants individually once the support session had concluded, using the pre-designed questions at the end of the checklist. It was important for these to be held privately and ensure the participant that the information would not be shared, so both participants felt they could speak freely. Post session discussions were not video recorded to keep the conversation natural, and the observer transcribed the participants' answers as they were provided. Students were spoken to first, followed by the practitioner. Where time constraints or opportunity to speak privately were an issue, participants wrote their answers directly onto the sheet themselves, where care was taken to ensure they were not able to see observation notes or the other participants' answers.

6.2.3   Sample

Observations were conducted at Coventry University from October 2022 – April 2023, The University of Northampton in May 2023, and finally Loughborough University in June 2023.

Coventry University and Loughborough University, both acknowledged leaders in the provision of MSS in higher education (Lawson et al., 2022), are comparatively large MSS providers. As of October 2023, Coventry MSS has nine dedicated support staff members, and one member of administrative staff. They also employ on an hourly rate three MSSAs (Mathematics and Statistics Support Assistants), two

PhD students and eight undergraduate student proctors. Additionally, thirteen teaching staff also provide some support hours each week. Loughborough University have eight support tutors, consisting of a mix of core, teaching staff, and PhD students, and four additional administrative staff members. Both institutions have a dedicated physical space for their support centre within their institution. Coventry University offers both online and in-person drop-in and appointment-based support, while Loughborough offers in-person drop-in with online bookable support. Conversely, the University of Northampton's MSS is considerably smaller, with only two practitioners offering the service. MSS at this institution is not stand alone and is a part of the learning development centre. It does not have a dedicated space and is based in the university's library. Northampton offers both online and in-person drop-in and appointment-based support. Although several of the staff at both Coventry and Loughborough are part time, it is clear from the above numbers that they are much larger provisions than Northampton.

Originally, 35 observations were conducted across the three universities, however four were not useable due to a corrupt recording and not receiving written consent. Therefore, this data set consisted of 31 observations in total, that lasted an average of roughly 34 minutes each, ranging from five to 70 minutes. 13 observations were conducted online and 18 in-person. Table 6.2 shows the breakdown of online and in-person observations conducted at each university.

	Online	In-person	Total
Coventry University	8	11	19
The University of Northampton	1	3	4
Loughborough University	4	4	8
Total	13	18	31

Table 6.2 Total online and in-person observations conducted at each of the three UK universities

Although online versus in-person support was the main focus of this study, additional conditions were also explored, namely drop-in versus appointment-based support, and mathematics versus statistics support. Of the 31 total observations, 15 were pre-booked appointments and 16 were drop-ins, and 12 were mathematics support sessions and 19 were statistics. Table 6.3 details this breakdown for each university.

		Online		In-person	
		Maths	Statistics	Maths	Statistics
Coventry University	Pre-booked	2	2	0	3
	Drop-in	0	4	5	3
The University of Northampton	Pre-booked	0	1	1	2
	Drop-in	0	0	0	0
Loughborough University	Pre-booked	1	3	0	0
	Drop-in	0	0	2	2
Total		3	10	8	10

Table 6.3 *Breakdown of observation type conducted at each of the three UK universities*

It is interesting to note that for in-person observations, the number of mathematics and statistics sessions observed were relatively similar, but with online observations it is heavily skewed towards statistics, especially as all four of the observations not useable were online statistics observations as well. This is consistent with experiences at Coventry University where online drop-in is now predominantly staffed by statistics tutors because most demand is for statistics support.

In total, 13 tutors were observed across the universities, nine at Coventry University, one at the University of Northampton, and three at Loughborough University. They were mainly staff specifically employed at their university as mathematics or / and statistics support tutors, referred to as core staff, one of whom was also completing PhD. Additionally, there was one PhD student providing support on an hourly basis alongside their studies, and one teaching staff member of the university who also offered support hours. As a result, years of experience ranged greatly, from 1.5 years to 31, with an average of 13.3 years. This also included general teaching experience for some. Four of the tutors were male (30.8%) and nine were female (69.2%). Table 6.4 breaks down this information for each university.

	Type of Tutor	Years of Experience		Gender	
		Avg.	Range	Male	Female
Coventry University	8 Core staff 1 PhD student	16.2	3.5 - 31	4	5
The University of Northampton	1 Core / PhD student	7.5	NA	0	1
Loughborough University	2 Core 1 Teaching staff	6.8	1.5 - 11	0	3

Table 6.4 Breakdown of the Tutor demographic information collected during the observations conducted at each of the three UK universities

Table 6.5 presents the gender, year of study and discipline of the students observed at each university, to explore if the types of students observed covered a range of MSS users. There were 34 students in total across the 31 observations.

	Gender	Year of study	Disciplines
Coventry University (n=22)	Male: 54.5% Female: 45.5%		• PhD • Nursing • Maths • Sport and Exercise science • Data Science • Engineering • Nutrition science • Psychology • Biomedical Science
The University of Northampton (n=4)	Male: 100%		• Engineering • PhD • Finance
Loughborough University (n=8)	Male: 75% Female: 25%		• Nutrition science • Finance • Natural sciences • Business • Maths and economics • PhD • Computer science • Engineering

Table 6.5 Breakdown of student participant demographic information collected during observations at each of the three UK universities

Apart from one observation at Coventry University where a group of four students worked with a tutor during an observation, each observation was one-to-one with a tutor and single student. More male students were observed than female, 64.7% to 35.3% respectively, but at least one student belonged to each year of study. These were one foundation student (2.9%), six first year undergraduates (17.6%), 10 second year undergraduates (29.4%), seven third year undergraduates (20.6%), four Masters students (11.8%) and finally six PhD students (including members of staff completing PhDs) (17.6%). The most common disciplines observed were in the field of sport and exercise science, but students came from a range of different subjects.

6.3 Data Collection for General Observations

The purpose of conducting general observations of the environment of a Mathematics and Statistics Support Centre was to explore what influence, if any, environmental factors of a physical centre may have on the students being supported. The focus of these was the behaviour of the centre as a whole, rather than specific individuals, where student usage, noise level, and busyness were monitored.

General observations were conducted at Coventry University only, and the following subsections detail how they were designed, carried out, and the sample collected.

6.3.1 Design

As with the tutor observations, a pre-designed checklist was created to complete during the observation (see Appendix 7). It was segmented into three sections for layout and functionality: student usage, atmosphere, and notes. As these factors were likely to change frequently during an observation period, for a more accurate representation, and to capture that change within a single observation, the checklist was designed for the observer to take 'readings' of the room at specific intervals. The structure was as follows:

- **Student usage:** How students use the physical support centre

- **Atmosphere:** Exploring the climate of the support centre

- **Notes:** Section to collect any additional information and details of the observation

Three possible uses of a physical centre were explored, specifically: seeking support with a tutor, using the centre as a workspace, or using the centre as a social space. Whether students were alone or within a friend group was also noted. Each of these five conditions were listed, allowing space to record how many students belonged to each of them at each observation point. Where applicable the observer was directed to note the number of friend groups and how many students were in them.

Student usage was explored because of the reported disadvantages of online learning, discussed in Chapter 2, and then subsequently found in Chapter 4 and Chapter 5. Practitioners often reported students

were missing the social side of in-person education, with students agreeing. Group work in particular was regularly mentioned as lacking in an online setting by both practitioners and students. Students also felt that they had lost the ability to sit in a space and work collaboratively and then access the support around them if they found they needed it. Therefore, usage was explored to see how students are now using the centre after the pandemic.

Volume and level of activity of the centre were monitored in the atmosphere section. They were represented as a question, and the observer would answer by using five-point Likert scales where the applicable level would be time stamped at each observation point. Each number in the scale was given a descriptive name appropriate to what level it represented, and the busyness scale also included an example. For instance, level three was described as 'Comfortable' with the added description of 'Regular flow of students'. This was to increase the measurability of these factors, as opposed to having them vague and up for interpretation, which could be more susceptible to observer bias. Additionally, a space was left to record any disruptions that may occur.

These factors were chosen to be measured because, as reported in Section 5.4.2.1, a student proctor of **sigma** explained that he had experienced students being deterred from using the centre due to the level of busyness. Additionally, as mentioned in Chapter 2, Mullen et al. (2023) concluded that the noise level was an important reason why students who had used both modes of support found the environment of the in-person support centre at University College Dublin (UCD) to be inferior to that in online support. Hence it was important to explore how climate can be influential.

Finally, a large area at the bottom of the checklist was kept free for additional notes and details of the observation, namely the time and date it took place. This was to ensure the checklist was not fully restricted to what had been chosen to be measured.

Due to the nature of these observations, obtaining student consent had to be thought about in a different way. It was important for this data collection to be as natural as possible, and asking for handwritten consent would obstruct that and also make the students identifiable. Hence, consent was achieved by where the students chose to sit in the centre. The support centre at Coventry University is an 'L' shaped room, where from the entrance students who are sitting around the corner cannot be seen. Hence a poster was designed to inform the students to sit in that location if they still wanted in-person support but did not wish to participate. With this option in place, students could tailor their own experience and support was disrupted as little as possible.

Support staff were purposefully not included as participants in the general observations, in the sense that no information would be recorded about them. Reasoning behind this was if they did not want to take part, they would be restricted to only helping students in the non-observed area. This way they could continue providing support regardless of whether the student being supported was taking place in the study or not.

6.3.2   Method

Students were recruited on a voluntary basis of those in the in-person support centre on the days the observations took place.

A trial was run to help decide how long an observation period should last. It was found that surveying the room in an hour period, starting at five minutes past the hour and taking a reading of the room every 10 minutes, allowed for six readings in total. The five minutes either side of the hour allowed for the settling of spikes in activity caused by support staff change over or lecture periods ending and starting. This was to ensure that the noise level and busyness readings were not influenced by these factors and would be a truer representation of the centre in that hour period.

The observer sat near the entrance of the support centre such that they could see the whole area of the centre being observed. The observation began on the hour. Although readings were taken periodically, additional notes could be made at any time throughout the hour period, and therefore the room was observed for the entire hour. It was important to still observe the area in between taking the readings as it could provide context for how students were using the centre. The checklist was again always completed digitally.

As students could easily change between usage conditions, a couple of important stipulations were made when completing the checklist. Students who were sat waiting with a ticket (A5 sized poster holder) to see a tutor were classed as seeking support, regardless of if they were working while they waited. If they continued to work after they had seen the tutor, identified by the ticket having been removed, then they were then classed as using the centre as a workspace if they were still present by the next observation point. To be classed as using the centre as a workspace, at the time a reading was taken students had to be seen visibly working. Sometimes students had their work set up but had moved to chat casually with their friends. If this had continued for more than a few minutes and was occurring at the point the reading was taken, they were classed as using the centre as a social space.

6.3.3   Sample

Observations were conducted in March and April 2023. This data set consists of seven observations, one carried out every hour period the support centre at Coventry was open for at the time of this study. At least one observation was conducted on each day of the working week, and one was collected during Coventry University's Spring study break for a comparison. Conducting the observations in this way was to account for any patterns of activity the centre usually had that could have skewed the data.

6.4 Data Analysis

6.4.1 Tutor observations

The data from the 31 completed checklists were transferred to a spreadsheet in Excel for easier visualization.

Count data was controlled for the length of the observation, as the longer the session the more chance the tutor has to display a behaviour. This was done by dividing the count by the length of the observation to find the rate per minute. Binary data was represented numerically, as 1 for 'Yes' and 0 for 'No'. These data could then be averaged for a comparison between test conditions. Likert scale data was kept as its raw score and the median was found. However, where the medians were the same for the two comparative groups, mean scores were then found for further comparison. For some observations some data is missing. This was due to human error and is explained in more detail in Section 6.5.1. Therefore, when averages were calculated, these observations were removed, but this is specified when reporting the results which this affected.

As this data set is small, descriptive statistics were the main focus of the analysis. However, some significance tests were used to check if any differences in averages between two conditions were significant.

For frequency and scale data, the Wilcoxon Rank-sum test was performed using RStudio. This is the non-parametric version of the independent sample t-test, which unlike the t-test, makes no assumptions about how the data is distributed. It explores whether there is a statistically significant difference between two independent samples. For the binary data, Fisher's exact test was used, again using RStudio. This test explores whether there is a significant association between two categorical variables, best suited when the sample size is small. In this case, the two conditions being compared, for example online or in-person, and the presence of a behaviour, 'yes' or 'no'. This information was first put into a contingency table which is a 2x2 matrix displaying the frequency of outcomes of the four possible combinations of variables. Fisher's exact test could then be performed on the table to assess whether a significant relationship existed between a condition and the presence of a behaviour.

Any additional patterns or differences noticed by the observer while conducting the study, outside of the behaviours chosen to be monitored by the checklist, were also reported.

Qualitative data, the transcribed answers from post-observation discussions, were collated into a single word document, grouped by question. Key points from both the tutor and student participants were then summarised and reported in the following section. Conclusions could then be made on how the participants vocalised opinion compared to the observations made by the observer. Skills acquired from repeated use of the general inductive analysis process, described in Section 3.5, aided in summarising

information. Additionally, some shared opinions throughout the discussion as a whole became evident while completing this process.

6.4.2   General observations

Data from the seven general observations were gathered together in Excel for easier visualisation. As the sample was very small, the main form of analysis was summarising key observations made.

Averages were used to compare student usage conditions. The quietest and busiest points during an observation for each usage group were explored. This was done by finding the lowest and highest number of participants present at any one point during each observation period and averaging it across the seven total observations.

6.5   Results for Tutor Observations

6.5.1   Online versus in-person exploration

Pedagogical techniques

All behaviours and student response criteria were averaged and compared across the two settings. Considerations were made for the significance of differences of all the behaviours on the checklist between the two environments, but due to the small sample size for this data set, the majority were found to be non-significant. Nonetheless, some comparative differences are still worth discussion as a basis for future exploration.

In the majority of observations, tutors were open and welcoming, more so in-person than they were online, in 94.4% and 76.9% of observations respectively. However, this was mainly displayed through their manner, such as smiling and tone of voice, rather than vocalised, where introductions were lacking in both settings. Obviously, this is not necessary for tutors supporting students that they had done in the past, but this was only stated in 29% of observations. As reported in chapter 5, some students would like support to be more approachable and familiar to make it easier to access. Lack of introduction could leave tutors seeming like a nameless resource rather than a supportive person wanting to help.

One element of support that was more challenging in an online environment was being able to utilise students' unspoken cues, which was regularly brought up as a disadvantage through the exploration in Chapter 4. This was even mentioned in the follow up discussion to one of the sessions, "*I prefer camera on, though you don't pick up many visual cues*". A good example of responding to unspoken cues in an online session was when a student went silent after an explanation, the tutor responded with "*I don't feel you believed me just now*". This prompted the student to reply verbally, and the tutor could then decide how to continue. This example came from an online session, where on average tutors actually responded to unspoken cues more than in-person, with a rate per minute of 0.018 and 0.008 respectively. For context, this would essentially be once per hour (1.08) session online and once per two-hour session

(0.96) in-person, which is over double the use online than in-person, but still very low for both settings. This will be further discussed in Section 6.7.

Answering higher order questions (HOQ) requires the student to go beyond providing simple information, having to use their knowledge and think critically to answer. Observed examples included "*how are you going to solve this?*" and "*so what does that tell us?*". HOQ was used at a rate of 0.03 per minute for online support and at a higher rate of 0.06 per minute for in-person. Conversely, drawing the information out of the student was used more online. This technique is similar to HOQ, in that those types of questions can help draw information out of a student. A key difference however, is that drawing information out of a student does not have to invoke critical thinking and can also be achieved in other ways such as using discussion to narrow their field of thought. Information was drawn out of the student at a rate of 0.07 per minute for online and 0.04 per minute for in-person. (Note averages come from one less in-person observation (n=12) due to missing data). This may be due to discussion being relied more upon in an online setting as visual communication is more limited.

Positive reinforcement is good practice when providing support to help build students' confidence. On average, this behaviour was observed three times during one online support session and twice in one in-person. When accounting for the length of the sessions, this was a rate per minute of 0.09 (to one s.f.) for both environments, the only behaviour to be used at the same rate in both settings.

There were only four observations where negative behaviours were displayed. Most commonly this was using judgemental language, saying the problem they were working on was 'simple'. However, for context, this was only used in a casual way, for instance, "*that's the easy bit*" before moving onto something the tutor deemed more complicated, rather than it being used to make the student feel incapable. The tutor may not have realised what repercussions that use of language could have had. Additionally, there was one instance of pressuring the student and one where the tutor spoke too fast at times.

Additionally, it is important to note that two years 'post pandemic', technological issues are still interfering with online support success. One student reflected somewhat negatively on their support session due to technological issues experienced when the tutor tried to draw work on a whiteboard. Other examples include a student having to leave a session midway through due to technology issues and one session experiencing technological glitches that forced them to change conferencing software mid-session.

Finally, a couple of significant differences between the settings were found and will now be discussed.

Body language has been frequently reported by practitioners as lacking in an online setting, particularly detrimental to helping them read their students to gauge their understanding. Therefore, it was interesting to explore if tutors used their own body language as much as they valued reading students'.

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In all in-person support sessions, tutors demonstrated the use of good body language. Good examples included rotating their body towards the student, physically pointing toward the computer or laptop screen, and hand gestures while explaining points. For the 18 in-person observations, the tutor using good body language was seen at least once in each session. For online support, in six of the 13 observations, tutors did not have their cameras on, and therefore it was impossible for them to use their own body language in a positive way. It is important to note that this is because Coventry do not require camera use during drop-in or appointment support when using BigBlueButton. However, in the remaining seven observations, good examples were displayed in two of them. These included instances of big visible nodding, and again the use of visible hand gestures.

Two considerations were made when exploring the significance of this. The first was if not using a camera (and therefore preventing the use of body language) was considered as a choice made by the tutor, and therefore was counted as the behaviour not being displayed for the analysis. The second was removing observations where a camera was not used, resulting in the total number of online observations becoming seven for this test. Fisher's Exact test proved both considerations were highly significant ($p < .001$), meaning tutors utilised their own body language in-person far more than they did online.

The choice of language when responding to students, particularly when giving them positive reinforcement, was also influenced by the setting of support. Using different methods of response in a support session, namely changing the way a tutor responds to a student, so it is not the same each time, is particularly important when correcting mistakes or confirming when the student did something correct. Examples of different praise that were observed included, "absolutely", "right" and "exactly yes", rather than just saying 'yes' each time. "Are you familiar with…" and "are you happy with…" were observed examples for when tutors introduced new concepts and checked for understanding. Delderfield and McHattie (2018) explain that this skill is important in showing the tutor is invested with the session and the learning of the student being supported; a quality some students praised online support for ensuring, reported in Chapter 5. It prevents the tutor sounding robotic. In seven of the 13 online observations, tutors used different methods of response, compared to in only three of the 18 in-person sessions. This difference almost reached significance ($p = .052$) using Fisher's Exact test, suggesting that tutors may have more consideration for their use of language and response in an online setting.

Student response

The comparison of student response to in-person versus online support sessions can be seen in Table 6.6.

	Online (n = 13)			In-person (n = 18)		
	Range	**Median**	**Mean**	**Range**	**Median**	**Mean**
Comfort	3 - 5	4	3.8	2 - 5	4	3.8
Change in Confidence	0 - 4	1	1.4	0 - 3	1	1.2
Engagement*	3 - 5	5	4.4	3 - 5	5	4.8

*Table 6.6 Comparing descriptive statistics of online versus in-person five-point Likert scale scores given to students during observations at three UK universities. * Denotes a significant difference.*

For all three response behaviours, the medians were the same for in-person and online observations. Hence for further exploration, means were compared.

Mean comfort level for students was actually the same in both settings, showing that students were equally as comfortable in a support session online as they were in-person.

No student appeared to have lost confidence after a support session. On average, students in an online setting gained slightly more confidence than those in-person. An increase in confidence was observed in 10 of the 13 online sessions, and 13 of the 18 in-person.

Finally, mean engagement score for students was 0.4 higher in-person than online, and this was actually a significant difference between the two settings using the Wilcoxon Rank-Sum test (W = 77, p = .039). Hence, students were significantly more engaged during in-person support than they were online. This very much supports students' opinion of the main disadvantage of online support reported in Chapter 5.

6.5.2 Exploration of other factors

Although comparing in-person support to online support was the main aim of this study, other areas of consideration were made as the study progressed. These were comparing pre-booked appointment support to drop-in support, mathematics support sessions to statistics support sessions, and large MSS provision to small. Key findings will now be discussed.

Appointment versus Drop-in

Appointment based support is pre-booked allotted periods of time working one-to-one with a tutor where the focus is solely on the student and their problem. They tend to be longer than drop-in support

sessions, the tutor often gets to know in advance what they will be covering and does not have to split their time between other students. This focus, although brought up during the questionnaire in Chapter 5 in the context of why they preferred online support, a student said "...*I find the tutor more focussed as they have no other distractions but helping me*". Therefore, this may also be applicable to appointments. Hence student response to appointment versus drop-in was explored, and a significant difference was found which is reported below.

	Drop-in				Pre-booked			
	Range	**Median**	**Mean**	**Total**	**Range**	**Median**	**Mean**	**Total**
Online	3 - 4	3.5	3.5	4	3 - 5	4	3.9	9
In-person*	2 - 4	4	3.6	12	4 - 5	4	4.3	6

Table 6.7 Comparing descriptive statistics of the five-point Likert scale scores rating students' comfort levels in pre-booked versus drop-in support in both settings during observations at three UK universities. Total column presents how many of that observation type was conducted * Denotes a significant difference

Table 6.7 shows the median and mean observed comfort level given to students in pre-booked and drop-in support sessions in both settings. As the median for in-person was the same for both online and in-person, means were calculated to explore both settings further.

Students were more comfortable in appointments rather than in drop-in support, in both an online and in-person setting. For the latter, students' mean comfort score for appointment support was 0.7 higher than it was for drop-ins, which was a significant difference found using the Wilcoxon Rank-Sum test ($W = 56$, $p = .029$). Additionally, mean comfort during drop-in sessions in both settings was marginally different, whereas students were more comfortable with appointments in-person than online.

The significant difference may have been influenced by the fact half of the in-person pre-booked observations were conducted at the University of Northampton, which has a much smaller MSS provision. Therefore, this was also explored.

Large versus Small MSS provision

As explained in Section 6.2.3, the University of Northampton's MSS team is much smaller than that at Coventry and Loughborough. Therefore, there are less faces to learn and so students may have felt the service was more familiar and consequently more approachable. Hence, the five-point Likert scale scores rating students' comfort level were averaged and compared between the two sizes of provision. Only one online observation in the data set was at Northampton, due to two of Northampton's online observations being unusable. Therefore, to control for influence of setting, only in-person observations were used for this comparison. This left 15 observations for large MSS and three for small.

The median comfort score for both large and small provision was four, and therefore average comfort score were explored. Students' average comfort level during observations at an institution with a large MSS service was 3.7 compared to 4.3 at the institution with small provision. This could suggest that students feel more comfortable with a smaller team, and therefore may have had some influence on the above finding that students were most comfortable during in-person appointments. It is important to note however the sample for Nottingham is very small and students may have visited the tutor before and therefore would appear more comfortable. This higher comfort level may also be due to the practitioner themselves rather than the smaller provision as only one practitioner was observed. This is a point of interest worthy of discussion but would need more observations to compare to see if this pattern holds true to make this conclusion.

Mathematics support versus Statistics support

The final area of additional consideration was the difference in pedagogy between mathematics and statistics support sessions and was explored for two of the practices on the checklist. This was based on patterns that were noticed by the observers when conducting the observations. To control for any influence by the setting of the support session, use of behaviours by mathematics and statistics support tutors were explored separately for both online and in-person, and the average use per minute is displayed in Table 6.8.

		Average rate per minute	
		Online	**In-person**
Explaining rather than demonstrating	**Mathematics**	0.1 (3)	0.19 (7)
	Statistics	0.18 (9)	0.23 (10)
Drawing information out of the student	**Mathematics**	0.14 (3)	0.05 (7)
	Statistics	0.045 (9)	0.04 (10)

Table 6.6 Average rate per minute of the use of pedagogical techniques by mathematics versus statistics support tutors in an online and in-person setting. The number in brackets is how many observations of that type were collected

Firstly, it was felt that during statistics support sessions, tutors explained more than they demonstrated. This may be because statistical analysis usually requires some form of software to analyse the data, hence additional explanation is needed to teach the student how to use it. In both settings the rate per minute of displaying examples of explaining rather than demonstrating was higher for statistics support sessions. For online observations, rate per minute for statistics was 0.18 compared to 0.1 for maths, and for in-person, 0.23 for statistics and 0.19 for maths. Note that averages have come from 12 online

observations (three mathematics and nine statistics) and 17 in-person observations (seven mathematics and 10 statistics) due to missing data.

The other area considered was the difference in drawing information out of the student, picked up by the first independent coder. It was felt that with statistics, drawing information was required a lot more as many support sessions revolve around students' project work. Statistics tutors have to thoroughly explore exactly what it is the student is hoping to achieve so that they can provide the necessary guidance. Whereas for mathematics, often this is in the form of working through a problem and getting the student to produce the answers. This was supported by one of the practitioner participants in the post-session discussions when they stated that "*statistics is always a little more difficult at working out what people actually want*". However, the opposite was found. In both online and in-person the rate per minute of drawing information was lower for statistics. During online observations, rate per minute for statistics was 0.045 and 0.14 for maths, and in-person, 0.04 for statistics compared to 0.05 for maths. The former was significant to the 0.1 level using the Wilcoxon Rank-Sum test (W = 7, p = .088). Averages came from 13 online observations (four mathematics and nine statistics) and 17 in-person observations (seven mathematics and 10 statistics) due to missing data. This result may be due to the fact that on average statistics sessions were longer than mathematics. Statistics appointments ranged from eight minutes to 70, with an average of 37.4 minutes, whereas for mathematics the range was five to 58 minutes, with an average of 32.1. The drawing information out of the student may only be at the start of a statistics session and then not occur again.

6.5.3   Post-observation Discussions

Tutor Discussions

The most common opinion of the practitioner was that the session went 'okay' (67.7%), with 22.6% explaining it went well, and single instances of 'very well' and 'dire'. This may be indicative of natural modesty. The only practitioner to have felt negatively towards the session that they had just delivered explained it was due to the technical issue that occurred as a result of not possessing the equipment they usually had. Self-reported examples of good practice included reviewing previous sessions at the beginning, adapting to still provide help to students who had enquired about assessed work, setting the students' expectations at the beginning, and prompting the student to find the answer themselves. Improvements included getting the student to write more, giving more examples, talking less, and being more on top of technology either by utilising it more or overcoming issues that developed. In general, tutors explained that they felt positive when the student would seem to go away happy or more confident, or sometimes even just with a basic understanding. *"I think a session is always a success if I can help the student and they leave happy. If that happens, I'm not too fussed on anything else".* One additional response did not talk about their session, and instead took the opportunity to share their preference for teaching nursing students, particularly those with difficulties, in-person rather than online. They preferred having the ability to observe how the student broke down approaching a problem

which was much more achievable in-person. Similarly, another tutor also provided positivity for in-person support rather than online while providing their thoughts on the session.

For 81% of observations, tutors were fully confident that the student(s) they were supporting were not influenced during the session by being observed, with three stating that the student even completely forgot. The remaining 19% were tutors suggesting there may have been a small influence, for example keeping their camera off which they had not done in the past, seeming nervous or more anxious, and making more 'silly' errors. However, all of these statements were followed by the tutor either concluding that there was other evidence to suggest that the student was not influenced, or that it was only a 50% chance. No tutor confidently stated a student was influenced by observations taking place, and therefore it can be reasonable to claim students generally displayed natural behaviour. The majority of these judgements were based on previous general experience, however in 29% of observations it was mentioned that the tutor and student had worked together before, and therefore the tutor had past experience to verify this was the case.

Four of the thirteen practitioners were strongly confident in their ability. They expressed that the majority of the time they have the required subject knowledge to help students, and rarely found they could not help someone. Others used slightly less confident language such as 'sometimes' and 'occasionally', but still the highest proposed proportion of this occurring was 25% of the time. Years of experience did not seem to have an influence on how confident the answer to this question was. Some explained that it depended on the query as in general problems were faced due to needing more of an understanding of the subject area the problem belonged to as opposed to the mathematical or statistical content itself. A common solution described for when tutors were faced with a problem they were weaker on was to try and find a way to work it out, often utilising the knowledge of the student by working together. Others explained they could also fall back on the knowledge and skills of their team and pass queries on to someone more suited. Overall, none of the answers provided to this question stood out as overly lacking self-confidence, although one tutor did exclaim "*ask me on imposter syndrome days and this* [stated frequency of an inability to help a student] *might be more though*".

Additional comments ranged from session specifics, to support in general. Session specific comments pointed out non-regular occurrences, such as technology issues, peculiar queries, or additional comments about the student. General support comments involved opinion about areas of support. Another tutor shared their preference of in-person support. This mirrors a main finding from the practitioner exploration phase of this study, showing that even after two years of delivering online support, a preference for face-to-face support is still present. However, another expressed their praise for online support in that it is more flexible for the students. This benefit is reflected both in student opinion reported in the previous chapter and was the most commonly identified benefit to online learning by practitioners during Phase 1 of this study.

A theme that came up across the tutor discussion questions was the benefit of having a team, particularly to utilise different strengths. Four practitioners mentioned having colleagues with different areas of expertise, and valued the ability to share student queries that troubled them with someone else who may be able to provide the answer. One tutor commented that smaller institutions do not have this luxury.

Student Discussions

Students' response to their sessions was overwhelmingly positive, with only one student having expressed a negative opinion. This particular support session had had some technological issues, leaving the student feeling "*a little uncomfortable*". They then compared that tutor's support set up to another's on the team. They explained that the other practitioner had a set up that made both in-person support and online support feel identical. Whereas the set up with the tutor that was observed resulted in lengthier sessions and the student needing longer to understand. One student did not give their opinion on the support session they had just had, but online versus in-person support in general, explaining that "*online energy isn't the same*" and "*in-person you get a better feel and understanding*". This mirrors the most common opinion shared during the student exploration phase of this study, that an in-person setting fosters a better learning environment, particularly with ease of understanding. This shows that a year later this opinion is still present.

The remaining 29 answers roughly fell into four groups of positivity, 'alright' (3.4%), 'good' (48.3%), 'really good' (34.5%) and 'excellent' (13.8%). Students were generally happy if the tutor had responded to what they wanted and they had come away having had a problem solved or they understood a concept more. Many commented on the value of the session as well, "*so so useful, I couldn't do it on my own*". Overall, tutors were far more critical of the session than students, which supports the idea of natural modesty. This was also found in Mullen et al. (2023) where they discuss the 'surprising' finding that students rated both types of support highly when practitioners had concerns for the quality of their provision in Mullen et al. (2022).

Not including generic statements of praise of the tutor doing well or needing no improvement, the most commonly provided example of good practice, by far, was a tutor's explanation of concepts, stated by 42% of participants. They explained that the communication and language the tutor used, and the way problems and concepts were broken down into steps with reasoning provided, helped to better their understanding. Along similar lines, using good examples to aid explanation was mentioned by four participants, particularly alternative examples (12.9%), helping to apply concepts. Creating a comfortable environment, namely not rushing, or pressurising the student, keeping them motivated and not making them feel stupid was also mentioned by four participants. Closely related to this was three students praising the tutor's patience, particularly when the student was not understanding something. These students valued their tutors' ability to pick up when they were not understanding a concept and acting patiently as a result. Remaining responses were generic praise such as "*everything well*" and "*I*

think she was good", or stating that there were no improvements needed, "*nothing to improve, did well to teach me*". Only two improvements were actually suggested by students in response to this question. One was that the tutor should just give answers rather than try to pull them out of the student, and the other was writing equations and numbers down rather than just speaking them out loud.

In all but five sessions (83.9%), students said they had achieved what they had come to the session for, including one expressing they chose MSS over attending their lectures because it suited their learning style better. In three of the remaining five sessions, students expressed partial satisfaction. For two (one in-person and one online), this was because they had not yet reached a solution to their problem. For the third, it was the only session with a group of students, who stated they wanted the tutor to give them straight answers to their query on their assessed work. That session was also in-person. Finally, one student was not sure as they wanted to go away and review their notes from their online session first, and one stated a firm 'no', as they wanted to explore statistical analysis in their online session but was encouraged by the tutor to understand their data first instead. In terms of how this compared to what the observer witnessed, only five students' answers contrasted to how the observer thought the student responded to the session. Four of these cases were the observer thinking the student was not happy with the outcome of the session, usually through their body language or tone of voice, but they then claimed that they were in the post-session discussion. This could be due to participant bias, supplying the answer they think wants to be heard.

All student participants expressed they would use that type of support again, with many using very affirmative language such as '*definitely*', '*obviously*' and '*one hundred percent*', with some even stating they had already booked future appointments. However, answers did tend to be about using support in general again rather than the specific mode they had utilised for the observation. Nonetheless, some did give opinions of preference. One student stated that as a distance learner she had no problem with online, with another explaining how she booked online as it was easier with work commitments. The same student however did then express a preference for in-person due to the learning environment, again reflecting student opinion reported in Chapter 5. Another also stating this preference unless tutors provided support in both settings that was indistinguishable from each other. Finally, one student stated, "*either in-person or online the outcome is the same*".

Additional comments from the student participants also ranged in content. Three students took this opportunity to praise their MSS service, commenting on areas such as ease and the necessity of having such a service. Of 11 answers in total, flexibility was commented on three times, namely the ability of students to access support from anywhere at their convenience. However, one student, who explained he was a distance learner, which is the student group regularly reported to benefit most from this flexibility, was very passionate about their preference of in-person. He exclaimed that *"having tutors online is the worst thing ever, if you truly want to learn it's not good and that's coming from an online*

tutor [in another context] *himself...I would rather travel for MSS in-person than online"*. Interestingly, one student explained he was not aware online drop-in support was available and happened to find it and drop-in at the correct time. This links to a key finding in the previous chapter, where students' most common reason for not using support was awareness, showing a year on that this is still prevalent. Finally, one student expressed his trouble with the length of appointment slots, expressing that "*a man like me*" needs more time than what the service was offering.

A small theme across student discussion as a whole was the knowledge of the tutor. A few students praised the subject expertise of the tutor they had worked with, with two explaining that that was the reason they always retuned to that specific tutor. However, this can work both ways, with one student explaining that the ability of the tutor was 'daunting' as "*she* [the tutor] *is very good at maths and I'm not*".

Overall, themes brought up by both participants discussed in this section focused more on general attitudes to MSS, rather than pedagogical aspects specifically. However, this may be due to the questions not directly asking about pedagogical techniques. A shared theme across both sets of discussions was participants sharing their opinion of online versus in-person support, although not directly asked. Their opinions, however, were very much reflective of the opinions shared by their peers during the associated exploration in the previous stages of this PhD study.

6.6   Results for General Observations

The following subsection details key observations made while observing the general environment of the **sigma** support centre at Coventry. It is important to note that apart from one exceedingly busy day, the centre was relatively quiet compared to earlier on in the year as the general observations were carried out during and after the exam period at Coventry University. However, some patterns did still emerge, and Table 6.9 shows a breakdown of students' average use of the centre.

	Lowest number present (Avg.)	Highest number present (Avg.)
Sat alone	1.7	2.9
Sat in groups (number of groups)	0.0	0.9
Seeking support	0.3	1.1
Using the centre as a workspace	0.4	2.1

Table 6.7 The average lowest and highest number of students present in a usage condition explored during general observations of an MSSC

Time	Usage readings		Busyness Readings	Noise level readings
16:00 – 17:00	Alone:	8, 8, 7, 6, 6, 5	3 (comfortable),	2 (Quiet),
	Groups:	0, 0, 0, 0, 1(2), 1(2)	3,	3 (Comfortable),
	With Tutor:	2, 2, 2, 2, 1, 1(2)	3,	2
	Workspace:	4, 2, 2, 3, 5, 5	4 (High),	2
	Social space:	0, 0, 0, 0, 0, 0	5 (excessive),	3
			3	2

Table 6.8 The busiest general observation data. Six readings of the MSSC environment every 10 minutes from 16:05 – 16:55

Students more frequently used the centre alone than they did in groups. At least one group of students sitting together in the centre occurred in only four of the seven observations, compared to six observations where at least one student was alone.

The average lowest number of students sat alone in the centre during an observation period was 1.7, compared to zero groups. The average highest number was 2.7 students sat alone to only 0.9 groups. There were a couple of instances of where a student would enter to meet a friend who was already in there alone and would later leave again while the other student remained. This contradicts findings from Chapter 5, where students commonly reported group work and sociability as benefits to in-person support that online was lacking.

However, the most common use of the support centre was as a space to work. The average lowest number of students working with a tutor was 0.3 compared to 0.4 being the average lowest number of students using the centre as a workspace. The average highest numbers were 1.1 students working with a tutor to 2.1 using the centre as a workspace. The centre was rarely used as a social space, occurring in only three of the 42 total readings taken across all observations. This may be heavily influenced by the time of year where students may be more focused on revising for exams than socialising. Many students were also observed continuing to work after a tutor had assisted them, with a few later picking up a ticket to join the queue for assistance again.

The busiest observed time period was 16:00 to 17:00 conducted on a Thursday. Noise level did not necessarily correspond with busyness level, with relaxed being the most common measure, most likely due to the centre not getting very busy during these observations. There was one much busier day, shown in Table 6.10, where when busyness reached excessive, but the noise level did not. On this day it was felt that students' need for support outweighed being put off by the level of busyness, as during one point the queue of students waiting was so long some had to be turned away. An interesting point to mention, that may be a result of students fearing the aforementioned situation, was that some students arrived over an hour before the tutor they wanted to see was due to arrive, with a view to secure an early position in the queue. However, it is important to note that general observations were conducted around Coventry University's project deadline period, and hence it was important to them that they got to see a tutor.

6.7 Discussion

The main aim of the study discussed in the chapter was to explore if there is a significant difference in pedagogy based on whether MSS is delivered online or in-person.

Tutors significantly utilised their own body language more in-person than they did online, despite having the view that a major drawback to online support was not being able to read students' body language. This may be due to the physical limitations of online learning itself, rather than rooted in pedagogy. Field of view is restricted in an online setting, often using a laptop or computer monitor that restricts your view of the student or tutor to the size of the technology you are using. When sharing content or using an online whiteboard, regular practice for online provision, this window of view becomes significantly smaller. Therefore, tutors may be subconsciously less aware of their body language as they know the student cannot see them as well. This idea is shared by Salvato (2023) for Professors' use of body language in-person. As a result, this may have caused an unconscious focus on the conversation and verbal pedagogical techniques instead.

Hence a potential reason why this study found that using different methods of response, changing language used to respond to students, was displayed more in an online setting than in-person. Delderfield and McHattie (2018) explained that for students to engage productively, they must feel that tutors care about their learning, and differentiated response was an example of showing this. This finding contradicts Armstrong et al. (2022), who although agreeing with this sentiment reported that students felt their educators showed less interest after transitioning online, which then reflected negatively in their opinion of their quality of learning online. This may be an emphasis on the difference between the nature of one-to-one support and didactic lecturing. A vital component of MSS is building students' confidence as well as their mathematical ability, particularly as common utilisers of support

are anxious, low-confidence students. So, when support transitioned online, tutors may have been more aware of the impact on students and therefore adapted accordingly by the language they chose to use.

An interesting finding was that responding to unspoken cues was used more during online support sessions than in-person, such as responding to periods of silence. This finding was counter intuitive as tutors have regularly reported their grievance at not being able to utilise unspoken cues in an online environment due to students regularly not having their cameras on. This may have been a result of tutors being more overly cautious in an online setting as a means to compensate, which was found by Naylor and Nyanjom (2021) to be one of the main four emotional orientations of HE educators in the transition to online delivery. When a student falls silent, the tutor does not have visual cues to read the situation to see if they are silent out of confusion, or for a different reason. As a result, they pause and check up on them verbally more regularly which is easier to pick up on in an observation than more subtle responses to unspoken cues such as adapting body language, or changing what they say next, which can happen unconsciously and simultaneously in-person. However, the rate of use was not frequent for either setting, possibly influenced by the length of a support session, and therefore, use of unspoken cues may only be thought to be of importance by practitioners, rather than in actuality.

The majority of pedagogical practices proved not to be statistically significantly different between the two settings. This is likely due to the small sample size. However, some statistically significant differences were found, suggesting that further investigations may be fruitful. If this is the case, a potential reason why may be because all support practitioners switched to online support at the same time, with many not having much, if any, prior experience teaching in an online setting. Therefore, the way tutors approached conducting their sessions, namely the pedagogical techniques they used and how they communicated to students, was to use what they knew - the way they used to teach in-person. The only thing that changed was the mode of that communication. Hence, elements that make up good practice for MSS in-person are replicated in good practice for MSS online, and there was minimal radical difference between the two settings. As a result, low self-confidence due to prior experience teaching in an online setting may have influenced previous findings that practitioners felt unprepared or trained enough to offer online support. This is supported by Bolliger and Halupa (2022) who found a significant positive correlation between HE instructors' level of confidence and their preparedness for online teaching.

However, in an online setting, some aspects or skills may become more important, or need to be used more frequently. For instance, with the added physical barrier of a computer screen between practitioner and student(s), being friendly and welcoming arguably have added importance, to avoid support feeling dehumanised. Additionally, more consideration of the choice of language needs to be given, taking particular care on how frequently the student is checked in with because of the reduced visibility an online setting causes. Supporting students online also comes with the added need to know how to

efficiently use appropriate technology, and potentially problem solve technological issues while also teaching.

The latter part of this study's research aim was to discover if a difference in pedagogy between the two modes of support had an influence on the students being supported.

Students were found to be significantly more engaged in-person than they were online. This supports findings in the previous chapter where the majority of students preferred in-person support, often explaining that the in-person environment fosters a better learning experience. They felt that it offered less distractions which increased focus and engagement and is easier to ask questions which aids their understanding. Recent studies conducted outside of the UK also found that HE students' engagement had decreased when learning was transitioned online (Walker & Koralesky, 2021) [USA]; Eika, 2021 [Norway]). One reason for this may be due to the environment, which was highlighted in Chapter 5, more than the pedagogical practices of the tutor. During the post session discussion, one student explained that they use online support for convenience but prefer in-person because the environment put her more in the headspace to learn. "*The atmosphere too, as a student you're there and in the mindset of learning, but while I'm at work my brain is split having to the think about the maths and work*". Although this comment may be comparing the work environment to the university setting, it is demonstrating the influence particular environments and associations can have.

It was observed that students seemed to be more comfortable during sessions at the University of Northampton, which offered comparatively smaller MSS provision to Coventry University and Loughborough University. Linking back to the previous phases of exploration of this PhD, during the practitioner interviews, some mentioned that students liked to visit the same member of staff. "*Some students will have uh favourite members of staff that they will drop in at the time those staff are on*". This may be because students familiarise themselves with one staff member and therefore feel more comfortable to go back to them. Students reinforced this theory during their interviews, "*If they already have a face, a familiar face, it could be easier to go in*", and again during post-observation discussions in this phase, "*...that's why he is always the one that I go to*". This is supported by Raby (2020) who found that a 'good proportion' of students would rather seek help from support staff who they already know rather than going straight to a service more relevant to their issue. This may be the reason why students displayed more comfort with smaller provision. Students were more familiar with the team because there were less people to familiarise themselves with and so they felt they knew the service better and hence more comfortable to utilise them. However, it is important to note that this is only a hypothesis requiring further exploration, as only one practitioner was observed at Northampton and therefore the higher comfort level may have been due to the practitioner themselves rather than the smaller MSS provision.

There was also a significant difference in students' observed level of comfort between in-person drop-in and appointment-based support. This pattern, although not significant, was present for online support also. This may be because of the level of uncertainty associated with drop-in support discussed in the previous chapter. With an appointment, it can be arranged over email or a booking system in advance, and the student is supplied with a name in readiness where all they then have to do is arrive for a guaranteed period of time with a tutor. The student also has the comfort of knowing the session is dedicated to them rather than the tutor's attention being divided. Conversely with drop-in, the student has to explain themselves on the spot, to which there is an element of risk that the most suitable tutor is not available, or the centre is too busy to supply that student with the required level of attention. This is support by Mullen et al. (2023) who found students' most desired improvement to in-person support, regardless of their usage type, was more private sessions.

Finally, general observations of the environment of a support centre showed that students mostly used the space as an area to work, closely followed by seeking help from a tutor, but rarely as a social space. Students also more frequently sat alone than they did in groups, which is unexpected. Opinion reported in this PhD study of both practitioners and students, was that online support does not foster a sense of community or provide opportunity for group work. Hence you would expect to see it occurring more now that in-person is possible again. This may have been influenced by the time of the academic year the general observations were conducted in, as it was during or after Coventry University's exam period, students are likely to have been on different timetables than their peers. An alternative possibility is that this opinion may have been heightened by a burn out from the pandemic, because socialising was restricted in all areas of life, and therefore community and group work was a lot more sought after once a return to in-person was possible. Three years post pandemic this new-found appreciation may have begun to level out.

6.7.1   Limitations

The largest limitation of this study was the small sample size, which could be responsible for the majority of non-significant findings. Larger sample sizes are more representative of the population being explored as outlying data does not have as much of an influence on the averages calculated. However, for this instance, time and resources, as-well as student uptake of support services, limited the number of observations that could be conducted. It was deemed that a sample of 31 was reasonable for this exploration and offers an interesting foundation for future research. Yet to make results more reliable, more observations should be conducted following the same procedure.

General observations were only conducted at one point of the academic year and therefore would be influenced by general university student activity of that time. To combat this, general observations could be conducted again at different points throughout the academic year, but again this was not possible due to time constraints.

Understanding of good checklist design and of the behaviours being explored grew over the data collection process. Due to the novel approach, issues arose that were brought to light after experience of completing the checklist several times, and also conversations with the independent coders. The checklist needed to be more specific in that it required more information as to what the behaviours were and how to record them. Sometimes it was forgotten which were to be simply confirmed and which were to be counted. Converting frequency to binary was fixable, but the opposite was not and so that resulted in gaps in the data. This issue was addressed for when the independent observer completed the checklist, where it was specified which should be counted and which checked, but they still had a challenging time completing it due to behaviours being left up for interpretation in some instances. Therefore, it was deemed brief explanations or examples of the behaviours could be beneficial to be included. This was again addressed for the second independent coder where a video was supplied detailing this additional explanation. This was also improved upon for general observations, where examples and specificity of how to complete the checklist was included. This issue could have been avoided with more trailing or more independent researchers, but time and resources limited this, and this was addressed over the progression of the study. Due to the subjective nature of observations, observers' interpretations will likely somewhat influence observations made.

6.8 Summary

This chapter detailed the third and final phase of a three-phase investigation exploring mathematics and statistics support in the 'new normal': an exploration into pedagogy of in-person MSS provision compared to that online. Observations were conducted at three UK universities observing MSS tutors supporting students in-person and online comparing the use of pre-determined pedagogical techniques, and the resultant response from students. Additional levels were also explored, namely appointment versus drop-in support, mathematics versus statistics, and larger versus small provision. General observations of the environment of an MSSC were also conducted monitoring how students use a physical centre.

Descriptive statistics were used to compare observation data between the settings, and consideration was made for the significance of differences found, however the majority proved non-significant. This is most likely due to the limited sample size, but it cannot be dismissed that pedagogy may not be different because support practitioners mainly used what they knew from teaching in-person. Interesting differences between the two settings were still discussed, including responding to unspoken cues, students being more comfortable with small MSS provision, and the most common use of an MSSC being students working alone. There were some factors however, such as the use of body language and student engagement, that were significantly different between the two settings, and students were also significantly more comfortable in appointment-based support as opposed to drop-in.

7 Good practice of MSS provision in the 'New Normal'

The overall goal of this research study was to use the key findings from a multiphase exploration to create a framework of informed recommendations for what can be considered good practice of MSS in our new normal.

The study in its entirety is initially summarised before reiterating the answers to the first five research questions the study addressed. RQ6, the overall aim of this research study, is then answered in the form of providing recommendations covering the key factors: provision, student engagement, and advertising. Finally, suggestions for future work to build on the findings discussed through this thesis are suggested.

7.1 Summary of exploration

This research study consisted of three separate phases of exploration into MSS: the practitioner perspective, the student perspective (with a focus on barriers to engagement), and the pedagogy of in-person versus online support.

Phase 1 was a longitudinal exploration into how MSS provision, and MSS practitioners' opinions of the services they were providing, had changed over 13 months of varying pandemic restrictions. Data was collected at three sampling points: May 2020, January / February 2021, and June 2021. The first sample came from a compound open question on the Hodds (2020) questionnaire that was not included in the initial report. It asked participants how they thought online MSS should be approached. General inductive analysis of the 74 free text responses gave a first look into opinion during the crisis-driven transition. In January / February 2021, after a period of reflection and opportunity to adjust provision if necessary, twelve practitioners who completed the survey were followed up with an interview. Interviews consisted of 10 questions and answers were both summarised and analysed inductively. Finally, the last sampling point was just over a year after the UK was first sent into lockdown. A survey was conducted in collaboration with German MSS practitioners exploring the differences between MSS in Germany and in Great Britain and Ireland. There were 35 respondents to the 32 question GBI survey, which were analysed using descriptive statistics and the general inductive approach. All three data sets provided opinions from practitioners in institutions both inside and outside of the UK.

The focus of the second phase was student opinion of MSS, namely exploring users and non-engagers of MSS and their experiences two years after the initial COVID-19 outbreak. An exploratory mixed-methods approach was used, conducting a survey followed by interviews / focus groups. The investigation comprised of two studies, the first targeting specific student groups at Coventry University, and the second a larger scale exploration looking at any student at universities in England, Ireland, Scotland, and Norway. The questionnaire gathered a basis for the general student opinion which then informed the discussion points for the follow up focus groups and interviews. In combination the

questionnaire received 148 responses, and two focus groups and four interviews were held. Quantitative data was analysed using descriptive and some inferential statistics and qualitative data through summaries and general inductive analysis.

Finally, Phase 3 was an investigation into the pedagogy of online MSS compared to that of in-person. A structured observational study, with pre-determined identifiable behaviours of good and bad practice of MSS, was executed at three UK universities. Thirteen tutors were observed to compare how students were supported in an online setting and an in-person one. A sample of 31 observations with follow up private discussions with participants were collected, focusing on the tutor's pedagogical behaviour and their student's response. General observations of the environment at one of the institutions were also carried out. Quantitative data was analysed using descriptive and inferential statistics and qualitive data was summarised.

7.2 Summary of findings

This section provides the key findings in answer to the research questions proposed in this study.

RQ1: What mathematics and/or statistics support methods did institutions in the UK and the rest of the world offer prior to and during the pandemic?

- Prior to the pandemic, online MSS was offered comparatively much less than in-person support by institutions around the world, often consisting of only a website detailing their in-person service. In Hodds (2020a), the most common forms of in-person support were drop-in, appointment, and workshops. For online support in the UK, just over 70% (of 53) offered emails, but only a third offered online appointments, and two offered drop-in. For outside the UK, online drop-in and appointments were only offered by one and four (of 11) Irish institutions respectively, and for those in the rest of the world (ROW), online provision was mainly videos or emails.

- In May 2020, 94.3% of responding UK institutions offered some form of online support. The provision of online appointments (75.5% for mathematics and 64.2% for statistics) was much more common than online drop-in (34%). Online support was less widespread outside of the UK, but where it was offered, drop-in support was the focus. Drop-in support was offered by 27.3% and 12.5% of Irish and ROW institutions respectively, and only one Irish institution offered either mathematics or statistics appointments (Hodds, 2020a). This increased to 100% of sampled institutions offering some form of online support at sample points two and three.

- In January/February 2021 (sample point two), practitioners stated their provision was still solely online, although some institutions had managed to provide some in-person support again between UK lockdowns. Appointments were more commonly offered (9/12) than drop-in (5/12) and an email service was less common.

- In June 2021 (sample point 3), practitioners were asked what in-person and online support they had offered during October 2020 – February 2021. Provision was mainly still only online, only 27.3% of 33 institutions in Great Britian and Ireland had offered any in-person support. The most common online service was pre-booked appointments (91.2% of 34), followed by drop-in (64.7% of 34). The same pattern occurred for in-person provision.

- Practitioners in the UK, in the majority, did not provide or have been unsuccessful in providing collaborative online learning spaces, mentioned in January/February 2021 and again in June 2021. Yet for MSS in Germany, there has been a lot of success with online collaborative learning spaces, and this was their second most provided service in June 2021. This may be due to the differences in MSS provision in the two locations, or students' attitudes to software use and group work in general.

- Developing MSS staff to make improvements to MSS provision during the height of the pandemic may have taken a back seat in many institutions where the priority was the development of mainstream teaching staff to be able to deliver lectures and seminars.

RQ2: What were the *practitioner* opinions of online MSS provision at the start of the pandemic and how did these change as the pandemic progressed?

- Practitioners' opinion of online support grew more positive over the 13-month exploration. In Hodds (2020a), only 72% of practitioners stated that they would continue with some online support after the pandemic, which changed to 100% at both the January/February 2021 and June 2021 sampling points. Hesitancy and negativity changed to acceptance and positivity once forced to deliver support online, suggesting the unknown may have had an influence on opinion. There is still a preference for in-person support, present at all three sampling points. However, 'face-to-face is superior' became a less frequently mentioned attitude.

- In May 2020 practitioners were mainly uncertain. Not only was being unsure the most common theme of responses, but uncertainty was also present in other themes, where practitioners were unsure of their next steps. There was still some uncertainty in January/February 2021, as practitioners did not know if any other online support methods were possible. Uncertainty was less obvious by June 2021; however, it is present potentially as a result of having had more time to consider the future of online support, and opinions of advantages and limitations not being as strong as previously.

- Practitioners felt flexibility and accessibility are the most beneficial elements of online support. Together they were the most frequently mentioned positive features in Hodds (2020a), accessibility appeared in the May 2020 open questions answers, the second most mentioned theme in the January/February 2021 interviews, and the highest mentioned advantage in June 2021. However,

it was mentioned noticeably less in June 2021 than previously, which may be a result of this benefit becoming the 'expected'.

- Lack of unspoken communication, commonly as a result of students not having their cameras on was heavily important to practitioners in January/February 2021. Practitioners felt as a result, it was harder read students, and judge if they were engaged, which was also identified as the largest barrier to online support in Hodds (2020a). But in June 2021, there was more of a split opinion. As only 5.7% of practitioners felt that students always had their cameras turned on at this sample point, showing that perceived camera usage had little to no change from sample two, something else may have potentially caused this divide in opinion.

- Advertising concerns were brought up in January/February 2021, expressing an idea that improving advertising could increase student engagement. Practitioners suggested methods such as student testimonials, targeted advertising, and introductions in-person so students had a familiar face to go back to.

- In both Hodds (2020a) and January/February 2021, practitioners considered that statistics support was less influenced by the pandemic and that students may even prefer it online because sharing screens and using software is easier as they do not have to crowd around one or multiple screens. However, the opposite was mentioned by a statistics practitioner in the 2023 observations that when a problem is complex, and you have multiple screens to share, it does not work well online.

RQ3: What is the *student* opinion of MSS provision and its effectiveness since the pandemic?

- There was a significant association between year of study (p = .0021), and discipline (p = .0017) with the type of MSS used by respondents in the questionnaires. Year of study is to be expected as different year groups had different modes of MSS available to them. For discipline: Health and Life Sciences students used online only the most, Mathematics and Education students were the most frequent users of both types of support, and Sports Science students were the highest non-engagers. In-person only was most commonly not used by disciplines, and among those that did, used at similar if not the same level.

- Students highly value MSS as a service available to them, having often offered praise not only for the academic support but also the mental / emotional benefits as well for both modes. Yet, there was a clear preference for in-person support throughout the study. 77.8% of 54 respondents who had used both form of support stated this preference, as did 6/10 interviewees, and the most common reason for accessing online support was because it was the only option (suggesting if in-person was available they would have used that mode). More advantages of in-person support were given than disadvantages, as well as both advantages and disadvantages for online support. Having a preference of in-person support was also the most common reason for not engaging with online.

However, students highly value the benefits online support has to offer, and seven students (4/54 in the questionnaire and 3/10 in the interviews) even prefer online support, with one student stating nothing would encourage them to use in-person provision.

- The convenience of online support in terms of accessibility and flexibility was highly valued by students regardless of preference. These factors were brought up as reasons for online engagement, the most common barrier of in-person support, and the topmost mentioned advantages to online support. Respondents suggested that student groups benefiting from this were distance learners, students with an illness or disability, and mature students who often have outside responsibilities such as a job or childcare. Students of different usage groups were much more in agreement about the advantages and disadvantages of online support than they were of in-person, mirroring opinion in general.

- Communication, both written and verbal, and in-person being a superior learning environment (factors such as more engaging, improving understanding and less distractions) were regularly repeated, mentioned as reasons for engagement and preference, and as advantages of in-person support and disadvantages to online. Most particularly, it being easier to ask questions in-person was stated regularly throughout the study.

- Facilitating social interactions is valued by students. However, other positives or negatives to the different modes of support were mentioned more throughout the questionnaire, suggesting it is not as important as other concerns. Many enjoyed the environment of an MSS centre allowing them to work around and with others and for relationships to be built.

- Timing and scheduling issues were a regular concern for students. The reluctance to use support, particularly in-person, for fear of busyness, preferred staff not being available, or clashes with scheduled teaching. The most mentioned encouragement needed to engaged with in-person support was the improvement of availability, and busyness of the drop-in centre and availability of staff members was the most mentioned disadvantage.

- Advertising of in-person support was thought of more highly, with advertising of online support receiving almost double the amount of below average ratings (poor and very poor), from all respondents. Overall, students wanted more frequent, visual, and thorough advertising, most commonly advertising through academic staff in lectures. They want to know what exactly there is to expect when engaging with support methods, and why they should engage, not just what is on offer. Common misconceptions about MSS were still brought up, namely being judged, or thought of as stupid for their ability or the questions they wanted to ask, and that MSS is only for certain types of students. Advertising was suggested as a way to help battle these opinions as well. More online methods of advertising were suggested for advertising of online support than in-person. The

importance of advertising to all years not just first years was expressed throughout. Students also want MSS to feel more approachable, with the idea that being introduced to the tutors and knowing more about them making it easier to access support.

- The most common improvement to MSS students wanted to see was more specialised help, in terms of discipline specific, software, and ability level.

RQ4: What are the current barriers to student engagement with MSS and what can institutions do to reduce these barriers?

- The most common reason for not accessing MSS was that the student felt they did not need help (53.7% of 41 responses).

- Students were given options to select from for reasons for non-engagement. Not getting around to it and embarrassment were the joint top selected raw answers. After taking into account responses in the 'other' category and combining options together under an umbrella term, Table 7.1 gives the four most stated reasons why students did not engage with MSS.

Reason for non-engagement	%
Unaware (advertising issues)	26.8
I had not got around to it	24.4
Fear and dislike (Anxiety)	22.0
Embarrassment	19.5

Table 7.1 *The top four most common reasons, after rearrangement, 41 non-engagers stated as a reason for not utilising MSS and the percentage of those who stated them.*

- Being unaware of what services are available, or where to find them, were (in combination) the most common reason non-engagers stated why that had not utilised support. This was also a reason why some in-person-only users had been put off using online. Having better knowledge of services would encourage online-only users and in-person-only users to use the other mode. Engagers were asked why peers may not be engaging and students who had only used one type of support thought the most common reason was being unaware of services. Reasons suggested included never having heard of support, not knowing where to find it, not knowing what to expect, or being unaware of the benefits. Interviewees stated that encouraging students to attend is down to a change in the way advertising is done, putting emphasis onto approachability, reassurance, and shutting down misconceptions.

- 'I had not got around to it' suggests there are students that have struggled enough to consider using support and thought about doing so, but nothing had brought them to actually use it, but this may be an example of hiding the real reason for non-engagement.

- Affective reasons were provided more than in past research. Students who had accessed both types of support thought the most common reason for their peers not engaging was students feeling shy, scared, or embarrassed (53.8% of 39 responses). This suggests more non-engagers may be embarrassed and not want to admit it. This was followed by being unaware due to advertising issues. Interviewees suggested having friends to go to MSS with would make it easier.

- Only users of both types of support felt that motivation was a barrier to engagement, as did four interviewees. This is reflective of practitioner' opinion that more effort is needed by students to engage with MSS.

- Interviewees felt the most common reason for non-engagers was time constraints.

Potential ways on how these identified barriers could be overcome will be discussed in Section 7.3.

RQ5: Is there a significant difference in pedagogy based on whether MSS is delivered online or in-person and what influence, if any, does this have on students?

- For the majority of pedagogical practices, their frequency of use proved not to be statistically significantly different between the two modes of support. This is maybe due to the small sample size; however, some interesting differences between the two setting were found, with a couple being statistically significant, suggesting practitioners do make some adjustments to their pedagogy when tutoring in an online setting. These are marked in the associated bullets by an asterisk (*).

- Tutors were more welcoming in manner and tone of voice in sessions in-person than they were online, but verbal introductions were lacking in both settings. This may be due to the environment and being physically separated from a person looking at a screen reducing emotional closeness as well as physical.

- Responding to students' unspoken cues occurred more frequently in an online setting than in-person, which is counter intuitive to tutors' opinion of the importance of this pedagogical technique. Tutors may be deliberately focusing on unspoken cues in order to compensate for the reduced number of such cues in an online setting. Responding to unspoken cues was seldom used in both settings, however, which suggests that this technique is thought of as more important than in it is in actuality.

- Tutors showed good examples of using their own body language significantly* more in-person than they did online (p < .001). They may be subconsciously less aware of their body language as they know the student often cannot see them in an online setting.

- Tutors using different language in response to students occurred more frequently in an online setting, with the difference almost reaching significance (p = .052). The tutor's inability to access a range of unspoken cues, particularly when the student did not have their camera on, may have caused an unconscious focus on verbal pedagogical techniques.

- Students' observed levels of comfort were the same in both settings but observed confidence increased slightly more in online sessions than in-person. Students were observed to be significantly* more engaged during in-person support than they were online (p = .039), which reflects students' opinion of in-person versus online support.

Finally, RQ6 needs to be addressed. The overall aim of this research study was to explore what constitutes good practice in MSS provision in the 'new normal', which will now be answered in the form of a framework of recommendations based on the key points discussed in this section and reported throughout this thesis.

7.3   Recommendations for future practice

7.3.1   Provision

Format and structure

- **Both in-person and online support should be offered if resources allow.**

Student and practitioner preference indicate that in-person support should be offered more than online support. However, completely removing an online synchronous option would alienate certain student groups, particularly as the data in this study showed a small percentage of students even prefer the online setting. This study has shown students highly value the flexibility and accessibility of online support, and those reported to benefit from online learning during the pandemic are still benefiting from it now. This is still particularly important for students who struggle to travel to campus (for example, distance learners, students of multi-campus institutions, mature students, placement students, and students with disabilities). It is important to consider how much of the identified preference is still influenced by burnout from the pandemic, and whether it will be the same in years to come.

- **Offer more appointment-based support at a range of different lengths.**

Reported during Phase 3 of this study, many students seemed to be more comfortable in an appointment setting as they enjoy the security of having the tutor's attention not split between multiple students. Offering more appointments than drop-in hours, as was the common pattern in institution's provision a year on from the initial outbreak, will save time and human resources if students do not show up.

However, it is important to also offer drop-in support, as students' queries may only be small and therefore taking up a longer appointment slot would not be time efficient. Also, pre-booking takes longer to receive help and therefore would not be worth it for quick queries. Having greater flexibility with appointment lengths could also help cater to different abilities of students and the extent of their query. Students can register their interest in a slot with their query, and then a tutor can validate how long they feel may be needed.

- **Offer specialised support or specialised resources from lecturers.**

The most frequent suggestion for improvement to MSS was more specialised support. Hence, if possible, staff for specialised subjects should provide some support hours on a weekly basis, for example, computer scientists, pure mathematicians, or physicists. These can be academic teaching staff, or masters, or PhD students in relevant disciplines. These additional staff should have knowledge that goes beyond the general knowledge of the MSS tutors. This can help bridge the gap between MSS and broader disciplines, as having that presence will make MSS seem like it is for them too, which could then lead to them accessing other support methods or other tutors. Student usage data should be explored to discover which subjects need representation the most.

As well as this, or alternatively for institutions where recruiting extra staff is not possible, MSS tutors could collaborate with subject specialists at their institution to create worked example and practice resources, particularly around assessed content. As discussed in Section 5.2.4.1, two applied mathematics students highly valued pre-assignment tutorial sheets provided to them in lectures which they could then take to their mathematics support centre for assistance, which bridged the gap in specialised knowledge. These resources should contain worked examples problems that clearly break the steps down with instruction and then provide practice questions to attempt. That way the MSS tutor can easily follow something that is not in their specialised area to assist students in more discipline-based areas. This would have the additional benefit of the student getting to see how someone else approaches content they do not instinctively know how to do. These can be uploaded to the institution's MSS webpage for easy access. This will also help to combat when students come and ask for support with an assessment as there is already material available to go through linking to but not directly addressing their query.

- **Develop a 'starting a session' protocol.**

An area for concern arising from Phase 3 of this study was practitioners being verbally welcoming. It is important to be open, welcoming, and approachable from the moment the student walks in the door or joins the conferencing software, particularly for students who have overcome a lot just to even ask for help.

For online, staff should have their cameras on at the start of the session. Students should be given the choice of having their cameras on or off and be reminded of that at the start, being made to feel

whichever choice is okay. However outside of the session, students should also be informed of the positives of having their cameras on during online support. Students may not have considered the hidden pedagogical benefits tutors being able to see their student can have. Posters, physical or digitally online, and social media could display this information.

The following three elements should be considered:

- o *Introductions:* Smile and begin by introducing yourself and asking for the student's name. For retuning students, if you have only seen them once or twice before, remind them of your name. If you remember theirs, address them by it when you welcome them; it can make them feel seen. If you do not remember their name, ask them to remind you. Tutors should be aware of their demeanour and tone of voice regardless of setting.

- o *Small talk:* Ask the student how they are before immediately jumping into asking how you can help them. This can also be an opportunity to read the student and see if there is any signs of stress or anxiety.

- o *Set expectations:* Ask the student how you can help them today. Once the student explains, set their expectations of what you hope to achieve. This is particularly important in instances such as them asking about assessed content, or if it is an area you are not as well informed on.

- **Foster a good learning environment online**

Students regularly identified that they feel an in-person environment generates a better learning experience, particularly asking questions being easier. Students should be regularly encouraged to ask questions if they have any. For appointments, students could submit a list of main questions along with their topic beforehand, that way, they only need to elaborate on the questions during the session. This would also allow the tutor to prep more in answering them.

Making it easier for students to communicate mathematical notation in an online setting can aid in the ease of question asking, which is discussed in the next section.

Technology

Technology and software is continuing to improve, but issues are still regularly being faced (evidenced by the technological issues witnessed during the observations conducted in mid-2023), which are impacting the success, and therefore opinion, of online support. The following recommendations could help to reduce the impact.

- **Create a record of technological difficulties.**

Every time a new technological issue is faced in a support session, it could be helpful to write down exactly what occurred. Then ways to overcome or prevent it from happening again can be explored. Create a resource of common technological problems faced and how to solve them for MSS staff to

refer to in the event that they experience the same problem. This resource could be created and shared cross-institutionally as well to make it comprehensive for all types of MSS provision. This links to the sharing experience sub-group of recommendations discussed below.

- **Extend sessions to allow for 'technology check-ups'.**

This recommendation is applicable to appointment-based support. Session lengths could be slightly extended to allow extra time at the start to set up required technology and check that it works. If the technology does work, the session can always be ended earlier. If there is an issue, hopefully it can be fixed in the additional time allowed so that the student still receives the appropriate length of time devoted to MSS without having to extend the time.

- **Providing an appropriate equipment list**

A recommended equipment list could be displayed, both in-person as a poster or leaflet, and online on the dedicated MSS website or notice / infographic on learning platforms. This list would inform practitioners and students alike what equipment is ideal to make online support run as smoothly as possible, namely a webcam, headset with microphone, and a means of writing mathematics online such as a writing pad, stylus, or touch screen device. Staff should be supplied with the necessary equipment to deliver successful online support if means allow.

However, not all students have access to this equipment. Therefore, particularly for those who are likely to be most reliant on MSS, but are faced with this issue, a loan scheme of equipment could be investigated. Equipment could also include laptops with required software downloaded to aid with statistics support. This can make it easier for students to communicate mathematical notation online, which as discussed in the previous section can make asking questions and showing their working easier. However, this will be limited by the resources and funding available.

7.3.2 Continual Learning by MSS staff

Building knowledge

- **Have knowledge of affective domain issues.**

Although the most frequently mentioned reasons for non-engagement were structural, affective reasons closely followed. Therefore, MSS staff should be knowledgeable on affective domain issues, decisions governed by emotion, and how students often try to hide behind structural reasoning, rather than admit when they are struggling with affective ones, such as embarrassment and anxiety. Tutors should pay particular attention to their own manner and language. Where students have had to overcome fear or embarrassment to come for support, casual comments from the tutor such as "that's the easy bit" could further exasperate those students' feelings if they did not think that part was easy.

The affective domain and how to identify these emotions within students, such as signs of anxiety, should be incorporated into training. Staff should be properly informed on how best to help these students.

- **Build awareness for mathematics and statistics anxiety.**

Fear and disklike, potential traits of mathematics and statistics anxiety, was the third most common reason for non-engagement, however not many students used the word 'anxiety'. Hence, Mathematics and statistics anxiety should be openly talked about, to reduce the negative connotations around it. Students need to be taught about what mathematics anxiety is so that they can identify it within themselves and not equate their struggles with their intelligence. Anxiety resources should be readily available to students should they feel they need it.

A way of achieving this can be to deliver a mathematics anxiety intervention. Gokhool (2023) reported the effect of a mathematics anxiety intervention in promoting engagement with MSS. The intervention consisted of exploring students' pre-existing ideas about mathematics anxiety and mathematics resilience, informing them of models of anxiety and encouraging them to share their own experiences, and finally informing them of strategies that could be used to help overcome anxiety including the use of MSS services. Over half of the students that took part in this intervention went on to engage with MSS after doing so and so the author concludes that an intervention can help change perceptions of MSS.

- **Staying aware of the latest technological advances.**

Linking to the earlier technology recommendations, some technological issues simply cannot be fixed at present as the technology may be at the forefront of its kind. Staying up to date with technological advances will allow for new options to be adopted if means allow. This includes training staff on how to use any new technology that will be implemented, particularly important for new software. These training sessions can also help to decide how user friendly the new methods are and hence if it best suits your institution.

Sharing experience

- **Larger institutions need to take the lead on experimenting with new approaches**

The pandemic has demonstrated how beneficial (and potentially crucial) sharing experience can be, where reports such as Hodds (2020a), and events held by the **sigma** Network and the IMLSN, allowed institutions to essentially work together to provide successful MSS in an uncertain time. This is particularly valuable for smaller institutions with less resources and staff. Larger institutions can and should experiment in new approaches to advance best practises, where smaller institutions cannot and therefore have to rely on what is shared by those that can. Methods applicable to a large institution may not always be applicable to a smaller one, but it gives a starting point to explore, and evidence to help weigh up if new approaches may be successful.

- **Different types of tutors could benefit from observing each other**

As found during the observations conducted in Phase 3, different tutors may use different pedagogies. Hence, it could be beneficial for tutors to observe each other. It may be particularly beneficial to observe a tutor with different characteristics. For example, a mathematics tutor might observe a statistics tutor; a new tutor might observe an experienced one; a general MSS tutor might observe a specialist from an academic department and vice versa in every case. The observation should be followed by a conversation. The aim would be that both parties could learn something from the other, adopting elements into their own practice they may think are useful.

This is an example of mutual benefit, where both parties of the exchange can learn something from the other. The work of Hodds (2020c) saw mutual benefit occurring between MSS and the School of Nursing at Coventry University. In exchange for a support practitioner delivering an intervention session to nursing students, nursing staff members would provide some hours in the support centre in the aim to increase student engagement.

This could also occur across institutions which is reflective of the work of Emma Cliffe and Rob Wilson, who looked at a new way of evaluating the effectiveness of MSS by using a 'critical friend' (mentioned in Hodds (2019), p.16). The idea was that an expert from a different MSS centre came in and observed support and spoke to tutors and students to review the impact of the service.

7.3.3 Advertising

Structural reasoning, namely not knowing was MSS is or about the support services on offer, and not getting around to using it, were the most common responses students gave in this study as to why they had not engaged with MSS. However, as discussed, there is a debate on if students are always completely truthful in the reasons they give for not engaging, with the possibility of hiding behind structural reasons rather than admitting their true affective reasons. Nonetheless, it seems highly unlikely that every student stating they did not know of MSS or where to find it are not being truthful. Therefore, it is not in doubt that these structural reasons are preventing some students' engagement with MSS. Hence effort should be put in to readapting the approach to advertising, significantly shifting its focus, and if students are still not engaging, it would strongly suggest affective reasons are likely to be operating.

In response to student opinion, there are two key aspects of advertising that need to be addressed: information and effectiveness, "*If the service was not only promoted, but promoted it was okay to not understand*".

Consider the following narrative that a student needs to follow so that they can engage with MSS and feel comfortable and confident doing so. Students first need to know about what services are on offer and why they would benefit from them personally. Once they have decided support could be valuable

to them, they need to know where to find it and how to access it. Now that they have decided to utilise support, they need to know what there is to expect when using the provision. Finally, once there, the environment needs to be approachable, inviting, and welcoming so the student can comfortably engage with the service.

| Awareness | → | Location | → | Expectation | → | Comfort |

Figure 7.1 *The advertisement narrative: The process of knowledge students need to go through to engage confidently with MSS*

The following methods can fit into these steps to help students on their journey to engaging with MSS, many of which were inspired by students speaking of their struggles accessing support during the student phase of this study.

Content

- **Utilise lecturers and repetitive advertising through lectures.**

For most students, engaging with lecturers is a weekly or even daily occurrence, hence lectures are one place where MSS advertising can reach a high percentage of the target audience. This method of advertising was suggested by staff and students alike and could be approached in different ways: simply asking teaching staff to mention MSS at the end of their lectures; creating a generic presentation slide for lecturers to access, adapt and add to their lecture material; MSS staff visiting lectures at the start of new academic terms. It is important that this is done regularly throughout the year, as students may not need support services at the start of term, but then find they have forgotten about the service by the time they do. Key but concise information should be shared such as an overview of the services on offer and where to find them.

To help build relationships with teaching staff, this could be explained as an opportunity for mutual benefit, where MSS gets more engagement and disciplines and lecturers see fewer struggling students. Demographic data can be used to see which disciplines are using the service, and this can also help with tailoring advertising to specific disciplines which will be discussed in a following subsection.

- **Have an easily accessible, visually appealing, multi-interface friendly website.**

This study has shown that advertising is crucial and for many, particularly those looking for online support, a website will be the first point of contact. Therefore, it needs to be easily accessible on multiple devices, and be visually appealing with accessibility concerns in mind.

The website needs to be attractive, but clear and concise. Students are not likely to read blocks of text, particularly if it is underneath the reason they came to the website for, for example the timetable. Important information should be at the top of the page before the main purpose. Website analytics, or

surveying known users of the website, can be used to see which pages of the website are used the most and important information can be targeted there. Bright colours and images should be used, but sparingly so as to not be too distracting. Colour contrast and titles, text, and links that are clear and meaningful should be used, particularly to be accessible for students with visual impairments, who may rely on a screen reader. For vital information contained in media, alternative next needs to be provided.

It is important for your institution's website to be multi-interface friendly, particularly both desktop and mobile. If a student spontaneously decided they want to book an appointment, or look up when support drop-in hours are, if they have to wait to access the website from a computer, they may lose that motivation.

A website is also a good place to introduce the MSS team to students, particularly those who cannot attend in-person. Supplying names, images, and short descriptions of both outside interests and areas of mathematics or statistics they specialise in can help to make the provision seem more friendly. It is important to include both so support practitioners are seen as more human. Students feel more comfortable talking to someone they know something about, and so by supplying them with a name, a face, and a skill area, they can target their desired tutor.

- **Create instructional videos on how to use MSS.**

Doing something unknown for the first time can be a daunting task, and for some even prevent them from stepping outside of their comfort zone. Knowing exactly what to expect when trying something new can help mitigate that fear. This is not only subject to students, as a practitioner also explained they liked to prepare, visualise, and think about a new situation until they felt comfortable to try it during the interviews conducted in Phase 1.

One way to achieve this is by creating instructional videos to help explain exactly how support services work and what a student should do if they want to use them. These should be visual step-by-step guides taking a student from the start of the process to the end, from opening up a web browser or stepping through the door, to signing off or leaving. Common questions new engagers may have should be addressed. These could be: where is it, do they have to sign in, do they have to speak to someone first, do they join a queue and how does that work, where can they sit, how long will they be waiting. For in-person services, video recorded footage of the support centre or location that support takes place can help a student familiarise themselves with the environment before having to be there and can help them picture themselves there.

Other videos could include shutting down common misconceptions (for example, it's only for struggling students, its only for maths students, I'll be judged for my ability etc.), student testimonials (explained in more detail in another recommendation) and introducing staff members. It is important

that videos are good quality, particularly on mobile devices as this is most likely how students will be accessing them.

A couple of current examples include a 'How-to' video from Loughborough University, explaining how their in-person drop-in centre works (https://www.lboro.ac.uk/departments/mlsc/mathematics-and-statistics-support-undegraduate/drop-in-support/), and a video from Queen's University Belfast using staff and student testimonials of their support service (https://www.qub.ac.uk/about/Leadership-and-structure/Faculties-and-Schools/Engineering-and-Physical-Sciences/mathsacademy/mash/).

- **Create signs directing students from the door to the support.**

To help students know where to access support, without having to overcome any additional fear in asking someone, navigational signage could be created. This was a popular suggestion from students during the exploration in Phase 2. Signs could be positioned from the main doors of the building and periodically repeated up to where the support is taking place, using directional symbolism. Creating a simple character or symbol to look out for, one that is regularly seen throughout the university, can make MSS seem more approachable and recognisable, almost making finding where support services are located a fun game.

It has been reported that a physical MSS centre is advertising in itself if students see it and walk in. But having a physical centre is not possible for all institutions. Hence adopting this approach can visually lead students to wherever the support is located, making up for the footfall a physical centre can create.

In the online environment, this could be achieved through eye catching banners, infographics, or icons on regularly visited learning platform pages. These could be hyperlinked themselves, or contain a hyperlinked image or text, that takes the student directly to the online support page. QR codes could also be used in the physical environment to take students directly to online support, where they can bookmark it for future use.

Approachability

- **MSS staff should be introduced to students after each new intake.**

It has been discussed in this thesis that students like to have a familiar face to seek assistance from. It is often that repeat engagers, students who utilise MSS more than once, want to go back and see the tutor that supported them on their first visit. This is because they found that experience helpful and that tutor did not judge or embarrass them and therefore they felt comfortable. This links to students needing to know what to expect. Knowing MSS staff prior to engaging with support can help make a student feel like it is a bit less unknown. MSS practitioners could be introduced to new cohorts at the start of each intake. How this could be achieved will be institutional dependent, but, if possible, for disciplines

that would benefit from support, during induction weeks a slot could be scheduled for students to do this.

Additionally, during open days or tours throughout the year, it should be ensured that ambassadors conducting campus or library tours are trained and informed to take a moment to go into support centres or areas, and explain what support is on offer and a brief description of how it works.

- **Gather testimonials from users of MSS to use as advertising.**

Students reported that they wanted to know why MSS would benefit them on a personal level, and one impactful way this can happen is to hear it from their peers who found this out for themselves. Testimonials from students who have engaged with support can show firsthand the impact MSS has had on students from different perspectives and gives MSS a voice that is closer to the target audience. This can be done by posters or social media posts with written quotes, or potentially more powerfully, getting students to appear on camera and make video testimonials. This could also be an opportunity to breakdown common misconceptions students have about MSS as mentioned earlier; hearing it from a peer might make it more impactful.

Feedback can be gained through methods such as physical feedback slips, a discussion board with QR access codes around the centre, an email address used specifically for feedback, or feedback questionnaires targeting engagers. A collaborative web-based platform such as Padlet, one of the feedback methods Coventry University currently use, can be particularly useful for collecting feedback from online support users.

- **Utilise social media to increase approachability.**

The use of social media was regularly suggested by students in Chapter 5 of this study. Social media can be a good way of making MSS seem more approachable; a chance to 'humanise' the service.

As a large use of social media is for entertainment, students are likely to scroll past bland looking posts. It is important not to just post about support services but stagger these uploads with other content such as pictures of the team, holiday posts, student feedback, fun quizzes, and videos. Creating a bank of posts ready to go can help achieve this. Building a following can be difficult, so using just one social media platform and building that up first may be beneficial. It is important to post regularly, but not to the point of burnout.

'Meet the team' posts can help familiarise students with the support staff if the above recommendation is not achievable. As described earlier, an image with a short description of interests both outside and inside mathematics / statistics should be included. These could also be in video form which may make it even more personal. Including easy access links to the MSS website on posts or page can allow students to access support information then and there.

Short diagnostics test questions could be used in a multiple-choice quiz format on social media posts, such as Instagram which has a multiple-choice quiz feature on its stories. The aim is to make it seem like a fun challenge, and then follow up with the answer asking if students got it correct and that if they had not, had they considered using MSS. This may help students identify their problem areas direct them towards MSS in a more subtle way than a whole diagnostic test given at the start of their degree, which may scare them right at the beginning.

Targeted advertising

- **Advertise MSS services to all academic years.**

Responses in the questionnaire suggested that older students feel less like they can ask for support, "*...it's hard to say you don't know what you're doing after a couple of years*", as they feel they should have a certain level of knowledge by that point in their degree. This was also found in Gokhool (2023). Additionally, students may have coped without the need of support in their first year but then found it progressively more challenging as they advanced. If students are only informed of MSS services in their first year, by the time they need it they may have forgotten about it. This would also further exaggerate feelings that MSS is only for first years. Hence it is important to make sure advertising is targeted at all academic years, including masters and PhD students, where the stigma is broken down that asking for help regardless of where they are in their studies, is okay.

- **Specialise advertising to disciplines.**

Making subject specific advertising can help bridge the gap between MSS and other disciplines, and break the impression that MSS is only for certain students, particularly those studying mathematics. As mentioned earlier, a generic slide of advertising could be created for lecturers to adapt to include the services that they feel are most useful to their discipline, or separate advertising materials could be created for each subject. This recommendation ties into the subject specialised staff / resources recommendation, which if advertised to disciplines that this is available to them, they will more likely feel that MSS is for them too.

- **Advertise at strategic times of the year.**

Advertising should not just be aimed at the beginning of the year. As mentioned above, by the time students feel they need support they may not remember what was advertised to them and have to find out about services themselves. Valuable points could be at the bigging of terms or in advance of exam / deadline season.

This could be particularly beneficial for the use of emails. Email overload was a common concern for practitioners in Chapter 4's exploration, yet the email was a reasonably popular suggestion of adverting improvement by students. Hence, strategically timing email advertising when students are not likely to get a number of others would be beneficial. Emails should also be concise and engaging with an attention grabbing subject to entice students to read them.

- **Monitor effectiveness of advertising methods.**

Although it was reported in this study that students want to see more advertising, they were often not specific as to by what means. Monitoring which methods are most effective can help target efforts and focus advertising on what students are responding to the most, rather than misspend time and resources on supplying more of a particular method that is not making a difference.

Methods of evaluating online advertising methods could include monitoring the number of times a link has been clicked on, or a video viewed; the number of visits to a webpage; and tracking social media interactions (such as views, likes, shares, and followers). Effectiveness of in-person methods can be evaluated through exploring how many times a QR code has been scanned; leaflet depletion; and student feedback on the environment.

Of course, the most obvious evidence on whether changes to advertising have been effective or not is the resultant engagement by students.

- **Monitor student opinion and engagement after changes are made.**

After implementing new advertising, it takes time to start seeing an affect. After changes to advertising have been made, allow sufficient time before then surveying students again for their reasons of engagement and non-engagement to see if structural reasoning appears less. Regularly monitor student engagement numbers and explore feedback.

7.4   Summary and Recommendations for future work

It was the aim of this research project to explore mathematics and statistics support and its effectiveness in institutions around the world since the COVID-19 pandemic caused a sudden change to online delivery. Provision, opinion, and pedagogy were explored with a view to produce recommendations for good practice of MSS in a post-pandemic society that would be beneficial to a wide variety of institutions. Although countries outside the UK were included, due to the language barrier, this international input was largely limited to English speaking countries. Nevertheless, it is hoped that the learning here could be taken and adapted and the findings used as a basis for comparison to extend an international look at MSS since the global COVID-19 pandemic.

One key difference between MSS provision in Great Britian and Ireland and that in Germany was the provision of online learning spaces. Practitioners in the UK have regularly revealed their struggle with providing these spaces, with reasoning such as technology and student uptake. Yet a key disadvantage to online support and online learning in general, held in opinion of both staff and students, was the lack of social and academic interaction. Hence it is surely of interest to explore this phenomenon further, if

attitudes to group work differ based on location, exploring if other countries outside if the UK have had more success, and why students in the UK do not utilise the resource, or if we have just not discovered the most efficient way of providing it.

It has been proposed that students use structural reasons for non-engagement to avoid revealing deeper reasons in the affective domain. This thesis did find more affective reasoning being given by students, but also still a large number of structural reasons were given both by non-engagers and by their engaging peers for why they thought students were not utilising support. Therefore, it would be beneficial to continue monitoring students' reasons for non-engagement to see if structural reasons are still prevalent in the future, particularly if the recommendations made in this thesis are adopted. If this is the case, it would be worth exploring additional ways in helping students feel more comfortable offering affective reasons in surveys.

It was interesting to discover that the difference in pedagogy between online and in-person support was not significant. However, this was maybe due to the small sample size. More observations considering the same behaviours explored here would need to be conducted with a view to explore whether this pattern still remains. This could also be an opportunity to review and improve the checklist to make it more comprehensive and applicable to other institutions. The scope of exploration could also be broadened for additional areas of comparison, having a bigger representation of other support staff such as teaching staff, PhD students and undergraduate student proctors. Additionally, students who have used MSS could identify 'excellent tutors' in both settings. These tutors could then be observed to see if their practice differs from that of their colleagues.

In general, there have been many recommendations for future practice of online learning made, including the ones made in this research project, in aim to overcome identified barriers and make it more effective. Now it would be valuable for future work to take some of these recommendations, implement them, and explore the resultant effectiveness and response. This work should be shared and built upon so good practice in online learning can become a standard in institutions across the world.

In summary, this thesis has shown how MSS provision at institutions inside and outside of the UK changed due to the COVID-19 pandemic. It has built on what is known about both staff and student opinions of in-person MSS and added how that compared to the newly experienced online delivery. It also offers a foundation for the novel exploration of pedagogical differences between the two modes of support via observation. This study provide a post-pandemic benchmark which gives a strong basis for comparison for future work, both to widen the scope and explore the change in provision, opinion, and engagement with in-person and online MSS in the future.

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Appendices

Appendix 1 – January and February 2021 Practitioner Interview questions

1. What online Mathematics and Statistics support is your institution offering?

2. Reflecting on what has happened in MSS since the pandemic, do you see any benefits from the new ways of working that have been introduced. And any disadvantages?
   a. Have you found your opinions have changed?

3. Are there any online methods that you are not currently offering that you would like to in the future? If so, what is holding you back in implementing these methods?

4. How are you advertising your online MSS?
   a. Do you feel it is successful?

5. How many students are accessing your service?
   a. Has this number changed since the beginning of the pandemic and if so, why do you think this may be?

6. Have you found a difference in engagement of different student groups?

7. In your opinion what do you think will make students engage with online MSS more?

8. When pandemic restrictions are lifted and we enter a new normal, would you continue with the online support methods your institution currently uses?

9. What are the biggest drawbacks of online MSS that need fixing? Any ideas about how they might be fixed?

10. What do you think MSS support will look like at your university when there are no pandemic-based restrictions on what you are permitted to do?

Appendix 2 – June 2021 Practitioner questionnaire

1. Name of Institution:
2. To which of the following target groups of students are the services offered in your learning centre addressed (choose all that apply)?
    - Students on Mathematics degrees (BA/MA)
    - Students from teacher education
    - Students from engineering courses
    - Students from other degree programmes
3. (Approximately) When was the maths learning centre at your university established (Year)?
4. What forms of online support have you offered from October 2020 - February 2021 (choose all that apply)?
    - Drop-in (i.e., without appointments)
    - Tutoring with prior appointment
    - Offer of open learning spaces (without tutoring)
    - Workshops
    - Other

   4a. For 'Tutoring with prior appointment', do students indicate the topic they want assistance with?
    - Yes
    - No

   4b. If you selected Other, please specify:
5. What forms of face-to-face support have you offered from October 2020 - February 2021 (choose all that apply)?
    - Drop-in (i.e., without appointments)
    - Tutoring with prior appointment
    - Offer of open learning spaces (without tutoring)
    - Workshops
    - Other
    - No face-to-face support was available [GREAT BRITAIN AND IRELAND ONLY]

   5a. For 'Tutoring with prior appointment', do students indicate the topic they want assistance with?
    - Yes
    - No

   5b. If you selected Other, please specify:
6. Overall, the Maths learning centre's services were used by students in October 2020 - February 2021 compared to the before the pandemic (October 2019 - February 2020):

	Much less	Less	About equal	More	Much more
Choose which applies					

7. Overall, the Maths learning centre's services were used by students in October 2020 - February 2021 compared to the last summer (April 2020 - September 2020):

	Much less	Less	About equal	More	Much more
Choose which applies					

8. Students with low self-confidence are more likely to use online support in maths learning centres than face-to-face support

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

9. Students with time constraints (e.g., children, part-time) are more likely to use online support in maths learning centres than face-to-face support

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

10. I think that word-of-mouth advertising about our learning centre is not as effective as it was before the pandemic

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

11. I think that students in the pandemic receive so much online information that our advertising is often overlooked

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

12. Providing maths (not statistics) support online is particularly challenging because of mathematical notation

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

13. Providing maths support online is particularly challenging because of technical problems

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

14. Providing maths support online is particularly challenging because of lack of student equipment (tablets and pens, camera, microphone; internet connection)

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

15. The ability of students to use digital media in the online learning centre is low

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

16. The ability of staff to use digital media in the online learning centre is low

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

17. Tutors or staff of our maths learning centre have the camera on during consultations

	Never	Rarely	Sometimes	Often	Always
Select that applies					

18. Students have the camera on during consultations

	Never	Rarely	Sometimes	Often	Always
Select that applies					

19. Online it is more difficult to determine how much students are engaging with the support provided

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

20. There is less cooperation and collaboration between students in an online maths learning centre than in an on-site in maths learning centre

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

21. Staff or tutors have to make more effort online than on-site to provide effective guidance

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

22. Students have to make more effort to learn online than on-site

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

23. Students have had greater non-academic burdens during the pandemic

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

24. Students have had less time or energy for study during the pandemic

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

25. The same interactions between students and staff or tutors take more time online than on site

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

26. For us as a maths learning centre team, online implementation has freed up time for other activities (better preparation of consultations, planning for the future, etc.)

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

27. The online operation of the maths learning centre has increased the time burden on staff or tutors

	Mostly Disagree	Partly Disagree	Neutral	Partly Agree	Mostly Agree
How far do you agree?					

28. [GREAT BRITAIN AND IRELAND ONLY]
Once a return to face-to-face operation is possible, our maths learning centre will:
- Return to a fully face-to-face offer (without any online tutoring)
- Continue to offer online tutoring, alongside face-to-face provision
- Offer only online tutoring
- Other

28a. If you selected Other, please specify:

[GERMANY ONLY]
Participants were asked to respond Yes or No to each of the following:

Once a return to face-to-face operation is possible:
- We plan to return to a fully face-to-face offer (without any online tutoring)
- We will continue to offer online tutoring, alongside face-to-face provision
- We will only offer online tutoring
- We also plan to offer workshops online
- Other (open question format)

29. How far has your attitude towards online support in the maths learning centre changed in the last year?
30. What benefits of online support in the maths learning centre do you see that have not yet been mentioned above?
31. What disadvantages of online support in the maths learning centre do you see that have not yet been mentioned above?
32. Do you have any other comments relating to online maths support?

The following are the additional questions on the German survey translated into English:

Questions about the person

Academic qualification (degree)

1. please indicate the highest degree of your academic qualification:

- Abitur (or comparable)
- Bachelor's degree (or comparable)
- Master (or comparable)
- Doctorate
- Habilitation

Type of position

2. which tasks and functions do you assume within the framework of the learning centre (multiple answers possible):

- Giving support to students
- Planning and organising
- Managing and leading tutors or staff members

Work experience in a learning centre

3. How many years of experience (as tutor or staff member) have you had in learning centres?

Appendix 3 – General Student Questionnaire

1. If you are happy to participate, please confirm your consent to continue. Otherwise, please choose the 'I DO NOT wish to participate' option to be screened out of the survey. Thank you for your time. *
   - I conform my consent
   - I DO NOT wish to participate in the survey

2. Name of institution:

3. Discipline:

4. Year of study:
   - 1st year undergraduate
   - 2nd year undergraduate
   - 3rd year undergraduate
   - 4th year or above undergraduate
   - Other
   4a. If you selected Other, please specify: *

5. To which gender identity do you most identify? *
   - Male
   - Female
   - Non-conforming
   - I prefer to self-describe as...
   - I'd prefer not to answer
   5a. I prefer to describe myself as: *

6. What type of mathematics and statistics support (MSS) have you accessed while at university? *
   - In-person only
   - Online only
   - Both in-person and online
   - I have not engaged with Mathematics and Statistics support

You have been taken to this page as you have accessed *'in-person only'* **mathematics and statistics support services at your university**

7. What in-person services have you accessed while at university (Please state all that apply)?

8. Please explain why you have currently only accessed in-person support services:

9. What has put you off using online support?
   9a. What would encourage you to attend an online support session?

10. How good/successful do you feel the advertising for in-person MSS services is?

	Very Poor	Poor	Fair	Good	Excellent
Choose which applies					

   10a. Please explain your answer: *

   10b. How do you think the advertising could be improved?

11. How good/successful do you feel the advertising for online MSS services is?

	Very Poor	Poor	Fair	Good	Excellent
Choose which applies					

   11a. Please explain your answer: *

   11b. How do you think the advertising could be improved?

12. What are some advantages and disadvantages of in-person mathematics and statistics support, if any?

13. What are some advantages and disadvantages of online mathematics and statistics support, if any?

14. Some students who would benefit from mathematics and statistics support are still not accessing the service. Why do you think that may be?

15. Finally, are there any methods of support, online or in-person, that your university is not currently offering that you would like to see in the future?

You have been taken to this page as you have accessed '*online only*' mathematics and statistics support services at you university

16. What online services have you accessed while at your university (State all that apply)?

17. Please explain why you have currently only accessed online support services:

18. What has put you off using in-person support?
    18a. What would encourage you to attend an in-person support session?

19. How good/successful do you feel the advertising for online MSS services is?

	Very Poor	Poor	Fair	Good	Excellent
Choose which applies					

    19a. Please explain your answer: *

    19b. How do you think the advertising could be improved?

20. How good/successful do you feel the advertising for in-person MSS services is?

	Very Poor	Poor	Fair	Good	Excellent
Choose which applies					

    20a. Please explain your answer: *

    20b. How do you think the advertising could be improved?

21. What are some advantages and disadvantages of online mathematics and statistics support, if any?

22. What are some advantages and disadvantages of in-person mathematics and statistics support, if any?

23. Some students who would benefit from mathematics and statistics support are still not accessing the service. Why do you think that may be?

24. Finally, are there any methods of support, online or in-person, that your university is not currently offering that you would like to see in the future?

You have been taken to this page as you have accessed *'both in-person and online'* mathematics and statistics support services at you university

25. What in-person services have you accessed while at your university (Please state all that apply)?
        25a. What made you use in-person support?

26. What online services have you accessed while at your university (Please state all that apply)?
        26a. What made you use online support?

27. Do you prefer in-person support, or online support?
    - In-person
    - Online
    - I do not have a preference

    27a. Please explain why: *

28. How good/successful do you feel the advertising for in-person MSS services is?

	Very Poor	Poor	Fair	Good	Excellent
Choose which applies					

    28a. Please explain your answer:

    28b. How do you think the advertising could be improved?

29. How good/successful do you feel the advertising for online MSS services is?

	Very Poor	Poor	Fair	Good	Excellent
Choose which applies					

    29a. Please explain your answer:

    29b. How do you think the advertising could be improved?

30. What are some advantages and disadvantages of in-person mathematics and statistics support, if any?

31. What are some advantages and disadvantages of online mathematics and statistics support, if any?

32. Some students who would benefit from mathematics and statistics support are still not accessing the service. Why do you think that may be?

33. Finally, are there any methods of support, online or in-person, that you university is not currently offering that you would like to see in the future?

You have been taken to this page as you '*have not engaged with mathematics and statistics support'* services at your university

34. Why have you not accessed mathematics and statistics support services at Coventry University (Choose all that apply)?
    - I do not need help with mathematics or statistics
    - I have not heard of sigma support services
    - I did not know how to find the support services
    - The times support is offered do not suit me
    - I'm worried my questions are too simple to ask for help
    - I'm embarrassed to ask for help
    - I'm worried my course tutors would find out
    - I meant to use mathematics or statistics support but some how never got around to it
    - I think mathematics or statistics support is only for struggling students
    - I don't like mathematics or statistics and so avoid it as much as I can
    - I am scared or mathematics or statistics so avoid it as much as I can
    - Other

    34a. If you selected Other, please specify:

35. How good/successful do you feel the advertising for in-person MSS services is?

	Very Poor	Poor	Fair	Good	Excellent
Choose which applies					

    35a. Please explain your answer: *

    35b. How do you think the advertising could be improved?

36. How good/successful do you feel the advertising for online MSS services is?

	Very Poor	Poor	Fair	Good	Excellent
Choose which applies					

36a. Please explain your answer: *

36b. How do you think the advertising could be improved?

37. Finally, are there any methods of support, online or in-person, that your university is not currently offering that you would like to see in the future?

Final Comments

38. Do you have any final comments regarding mathematics and statistics support at Coventry University?

Finally, would you be interested in taking part in a follow up focus group?

If <u>YES</u>, please click on the link to be given the ability to email Professor Duncan Lawson, an investigator on this study, to confirm you would like to participate. Please use your student email address when confirming your interest. We will not be able to link your email response to the answers given in this survey. Then close the mail application/window and click finish to end the survey.

If NO, please click finish to end the survey.

Appendix 4 – Student Focus Group questions

1. What do you think maths/stats support is? How do you think it works? *To make sure participants have a clear idea about this before moving on.*

2. It was suggested from early responses in the questionnaire that in-person support is 'easier' than online support. What do you think about this statement? *Many prompts may be needed for this question due to 'easy' potentially meaning different things to different students e.g., camera usage, technology, a face-to-face connection*

3. There have been a few responses on the questionnaire that have suggested that maths and stats support is only a place for maths students. Why do you think people may have this view? *Prompts could be to consider such things as "is it just for weak students? Students who have questions?" if discussion is slow to get going. Follow up questions:*
   a. Is this what you think? Who do you think maths/stats support is for?
   b. How do you think we could fix this issue?

4. What do you think is the most effective way to advertise maths/stats support to students?
   This was a key concern brought up by students in the pilot questionnaire. Prompts here include email (practitioners worries of danger of overload, not being read); lecturers (brought up by many in the questionnaire, how/when); social media (would students resent/ignore this).

5. In the questionnaire we asked students what potential reasons there may be for students who may need support not accessing it, and other than the advertising issues, a key idea was students feeling nervous or embarrassed to access support. Would you feel this way about accessing support? *Follow up questions to this:*
   a. What do you think we could do to help these students?
   b. Do you think this is the main reason why students do not engage with maths/stats support?
   c. Are there any reasons that just apply to in-person and any that just apply to online?

Appendix 5 – Questions asked to Gatekeepers for Student Phase

1. If you are happy to participate, please confirm your consent to continue by selecting the 'I consent' box below. Otherwise, please ignore the correspondence

   I consent ☐

2. Name of Institution: Click or tap here to enter text.

3. How long has mathematics and statistics support been established at your institution? Click or tap here to enter text.

4. What support methods did you offer prior to the pandemic?
   Click or tap here to enter text.

5. What support methods did you offer during the height of the pandemic (March 2020 – June 2020)?
   Click or tap here to enter text.

6. Did you use any online MSS methods during the subsequent academic year that you no longer use (September 2020 – June 2021)?
   Click or tap here to enter text.

7. What does MSS at your institution look like now (September 2021 onwards)?
   Click or tap here to enter text.

Appendix 6 – Tutor Observation Checklist

- Open and welcoming
- Good use of body language
- Demonstrated understanding of the student's situation
- Built the student's confidence
- Responded to unspoken cues

- Spoke clearly and confidently
- Clear writing
- Used higher order questioning
- Used silence appropriately
- Adapted to ability of the student
- Used different methods of response
- Positive reinforcement for success
- Honest

- Drew the information out of the student
- Explained rather than just demonstrated
- Tried to find the root of the student's problem
- Allowed student to attempt their own question
- Checked for the student's understanding
- Demonstrated multiple methods if required

- Talked too fast
- Pressurizes the student
- Used phrases like 'this is easy / simple' or 'you should be able to do this'
- Made assumptions of the student's knowledge
- Minimal eye contact

- How comfortable was the student?

1 (Uncomfortable)	2	3	4	5 (Fully relaxed)

- How engaged was the student?

1 (Distracted)	2	3	4	5 (Fully engaged)

- How confident was the student at the beginning?

1 (Completely unsure)	2	3	4	5 (Fully confident)

- How confident was the student by the end?

1 (Completely unsure)	2	3	4	5 (Fully confident)

- What body language did they use?

- Did they seem happy with the outcome of the session?

Session length:

Session type:　　In-person　　Online

	Practitioner		**Student**	

Practitioner

Participant number: ☐

Gender: _____

Years of experience: ☐

Mathematics or Statistics

Student

Participant number: ☐

Gender: _____

Year of study: _____

Discipline: _____

Practitioner

- How do you feel that tutoring session went? Is there anything you felt you did well or could have done better?

- Based on your experience, do you feel the student's behaviour was influenced by being observed?

- How often do you feel like you don't have the subject knowledge necessary to help a student?

- Anything you would like to say?

Student

- How do you feel that support session went?

- Is there anything you think the tutor did well or could have improved on?

- Do you feel like you achieved what you came in for?

- Would you use this type of support again?

- Anything else you would like to say?

Appendix 7 – General Observation Checklist

Please take readings every 10 minutes and mark down how many students in each of the following groups (*Where applicab██ ote number of groups and how many students in ea█*)

- ▪ **Students sat independently** (including with tutor)

- ▪ **Students sat in friend groups**

- ▪ **Students working with a tutor**

- ▪ **Students using the centre as a workspace** (not including waiting for tutor)

- ▪ **Students using the centre as a social space** (not working)

lease time stamp the applicable box at each observation poin█████

- ▪ **How busy is the center?**

1	2	3	4	5
Under utilized (0 students)	**Relaxed** (The odd student here and there)	**Comfortable** (Regular flow of students)	**High** (Long queue of students)	**Excessive** (Students unable to get help due to busyness)

- ▪ **What is the noise level?**

1	2	3	4	5
Silent	**Quiet**	**Comfortable**	**High**	**Excessive**

- ▪ **Any disruptions?**

Observation date: **Start time:**   **End time:**

Use to record any additional observations whenever applicable:

Appendix 8 – Example of a Participant Information Sheet

<h1 style="text-align:center">Participant Information Sheet for
Exploring the pedagogy of online versus in-person mathematics and statistics support</h1>

You are being invited to take part in research on mathematics and statistics support (MSS) measures and the exploration of pedagogical techniques of online versus in-person support. Holly Gilbert, PhD student in the Centre for Global Learning at Coventry University is leading this research alongside Dr Mark Hodds, **sigma** Mathematics Support Lecturer at Coventry University and Professor Duncan Lawson, **sigma** Director. Before you decide to take part it is important you understand why the research is being conducted and what it will involve. Please take the time to read the following information carefully.

What is the purpose of this research?
This project is an observational study investigating the pedagogy, of Mathematics and Statistics support measures at Coventry University. The global COVID-19 pandemic forced MSS online, and for the majority of institutions, little to no online support was offered prior. A survey on the changes of MSS practices was conducted at the beginning of the pandemic (Hodds 2020), and a key finding was that practitioners felt inadequately trained to be able to support students online to the level they could in-person. This research aims to discover if there is a significant difference in pedagogy based on whether MSS is delivered online or in-person and to explore what influence, if any, this may have on the students being supported. This research is aiming to help improve the pedagogy of online support to the level of pedagogy of in-person support.

Who is organising and funding the research?
The research is being organised and funded by Coventry University. The research was granted ethical approval by Coventry University's Research Ethics Committee, project reference: P140088.

Do you have to take part?
No, participation in this research is entirely voluntary. If you do decide to take part, please keep this Information Sheet so that you understand your rights in relation to the research. Please note down your participant number (which will be provided to you once you confirm you are happy to be involved) and provide this to the lead researcher if you seek to withdraw from the study at a later date. As we will not be recording your name, your participant number is the only way that we have of identifying your data. You are free to withdraw your information from the project data set at any time until the data are destroyed. You should note that your data may be used in the production of formal research outputs (e.g., journal articles, conference papers, theses, and reports) prior to the 18th of October 2024, when the data will be deleted. You can stop taking part during the observation at any time, with no reason for doing so necessary nor any repercussions, by informing the researcher. If the session is being recorded, it will be stopped and deleted immediately. Any notes taken will be deleted / destroyed. To withdraw at a later date, please contact the lead researcher (Holly Gilbert, gilberth2@coventry.ac.uk). Please also contact Professor Duncan Lawson, (mtx047@coventry.ac.uk) so that your request can be dealt with promptly in the event of the lead researcher's absence. You do not need to give a reason. A decision to withdraw, or not to take part, will not affect you in any way.

What will happen if I decide to take part?
We would like to observe, and, ideally, video record (if you and your students will consent for us to do so) the way you support students in the drop-in centres either or both in-person and online. During the observation, behaviours of both you and your student will be recorded using a pre-designed checklist

and will last as long as the student requires help for. Online, if the session is to be recorded, we will ask you to take the student to an MS Teams meeting (the link will be supplied to you and the student in the BBB chat and record the session. The observer will not be present. For observation only, the observer will be present, but with their camera and microphone off. In-person, if the session is to be recorded, the observer will set up the camera and move away. For audio recording or observation only, the observer will be sat at location nearby but out of eyeline. This because it is important you and your student feel comfortable and speak freely as normal. After your sessions, you will both be invited for a private conversation that should last no longer than 10 minutes. The purpose of this is to gather your opinion on the experience you just had. In notes taken by the observer and any other outputs from this study, you will only be referred to by a participant number or pseudonym.

Why have you been invited to take part?
You have been invited to participate in this research because you are a current mathematics and/or statistics support practitioner at Coventry University.

What are the benefits and potential risks in taking part?
By taking part, you will be helping Holly Gilbert in her PhD study, as well as progressing research on MSS being undertaken by supervisory colleagues Dr Mark Hodds and Professor Duncan Lawson. Fundamentally, the study will inform Coventry University's practices to better understand the impact that the strategies used to mitigate the spread of Covid-19 have had, and improve anywhere necessary. This study has been reviewed and approved through Coventry University's formal research ethics procedure.

There are no significant risks associated with participation, however, having your session observed is voluntary and you can stop at any time, with no reason for doing so necessary nor any repercussions, if you feel you need to do so. If after the observation you wish to remove your data, you can do so by contacting the lead investigator (Holly Gilbert, gilberth2@coventry.ac.uk).

What information is being collected in the research?
Information is being collected from observations, where behaviours of the participants are recorded using a checklist. Participants' thoughts and opinions of the session will also be collected together with a few demographic characteristics for comparison purposes e.g. gender, years of experience, discipline. The observation checklist will produce quantitative and qualitative data and further will be generated from any additional notes taken and the conversation.

What will happen to the results of the research?
The overall data from this research may be summarised in published articles, reports, and presentations. Quotes or key findings will always be made anonymous in any formal outputs, where participants will be referred to by a participant number or pseudonym.

Who will have access to the information?
Your data will only be accessed by the research team.

Where will the information be stored and how long will it be kept for?
Your data will be processed in accordance with the UK General Data Protection Regulation 2016 (UK GDPR) and the Data Protection Act 2018 (DPA). All information collected about you will be kept strictly confidential. Unless they are fully anonymised in our records, your data will be referred to by a unique participant number or pseudonym rather than by name. If you consent to being video recorded, all recordings will be destroyed once they have been analysed. Any physical notes will be scanned in electronically and then destroyed.

All electronic data will be stored on the Coventry University One Drive. Your consent information will be kept separately from your observation data. The researcher will take responsibility for data destruction, and all collected data will be destroyed on or before 18th October 2024.

What will happen next?

If you would like to take part, please respond to the lead researcher and complete the informed consent form before taking part.

Researcher contact details:

Holly Gilbert, gilberth2@coventry.ac.uk

Professor Duncan Lawson, MBE, mtx047@coventry.ac.uk

Who do I contact if I have any questions or concerns about this research?

If you have any questions, or concerns about this research, please contact the researcher, or their supervisor. If you still have concerns and wish to make a complaint, please contact the University's Research Ethics and Integrity Manager by e-mailing ethics.uni@coventry.ac.uk. Please provide information about the research project, specify the name of the researcher and detail the nature of your complaint.

Thank you for taking time to read this information sheet and for considering participating in this research.

Appendix 9 – Example of an Informed Consent Form

CONSENT FORM

Exploring the pedagogy of online versus in-person mathematics and statistics support

You are invited to take part in the above research project for the purpose of collecting data exploring whether there is a significant difference in pedagogy based on whether mathematics and statistics support is delivered online or in-person, and what influence that may have on the students being supported

Before you decide to take part, you must **read the accompanying Participant Information Sheet and Privacy Notice**

	Researcher	Supervisor
Name	Holly Gilbert	Professor Duncan Lawson
Department	Global Learning	sigma
Contact details	gilberth2@coventry.ac.uk	mtx047@coventry.ac.uk

This form is to confirm that you understand what the purposes of the research project are, what will be involved and that you agree to take part. If you are happy to participate, **please initial each box to indicate your agreement**, sign and date the form, and return to the researcher.

Please do not hesitate to ask questions if anything is unclear or if you would like more information about any aspect of this research. It is important that you feel able to take the necessary time to decide whether or not you wish to take part.

		Initial / Complete
1	I confirm that I have read and understood the Participant Information Sheet for the above research project and have had the opportunity to ask questions.	
2	I understand that all the information I provide will be held securely and treated confidentially. I understand who will have access to any personal data provided and what will happened to the data at the end of the research project.	
3	I understand my participation is voluntary and that I am free to withdraw my participation and data, without giving a reason, by contacting the lead at any time until the date specified in the Participant Information Sheet.	
4	I understand the results of this research will be used in academic papers and other formal research outputs.	
5	I am happy for the observation to be: *(please select ONE)*	Video recording Audio recording only Observation only
6	I agree to take part in the above research project.	

_____   _____   _____

Name of Participant   **Signature**   **Date**

_____   _____   _____

Name of Researcher   **Signature**   **Date**

Appendix 10 – Ethics Certificates for Phase 1

Certificate of Ethical Approval

Applicant: Mark Hodds

Project Title: Investigating changes in the mathematics and statistics support practices due to Covid-19

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval: 11 Jan 2021

Project Reference Number: P115826

Certificate of Ethical Approval

Applicant: Holly Gilbert

Project Title: Online mathematics support measures and their continuation post-pandemic

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval: 20 May 2021

Project Reference Number: P121356

Appendix 11 – Ethics Certificates for Phase 2

Certificate of Ethical Approval

Applicant: Holly Gilbert

Project Title: CU Engineering and HLS students' perspectives on
                               mathematics and statistics support (Questionnaire)

This is to certify that the above named applicant has completed the Coventry University Ethical
Approval process and their project has been confirmed and approved as Medium Risk

Date of approval: 14 Oct 2021

Project Reference Number: P126620

Amendment was approved for external exploration

Certificate of Ethical Approval

Applicant: Holly Gilbert

Project Title: CU Engineering and HLS students' perspectives on
Mathematics and Statistics Support (Focus Groups)

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval: 30 Nov 2021

Project Reference Number: P128908

Amendment was approved for external exploration

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Appendix 12 – Ethics Certificates for Phase 3

Certificate of Ethical Approval

Applicant: Holly Gilbert

Project Title: Exploring the pedagogy of online versus in-person
                                        mathematics and statistics support

This is to certify that the above named applicant has completed the Coventry University Ethical
Approval process and their project has been confirmed and approved as High Risk

Date of approval: 18 Aug 2022

Project Reference Number: P140088

Amendment was approved for external exploration

Certificate of Ethical Approval

Applicant:	Holly Gilbert
Project Title:	Exploring the pedagogy of online versus in-person mathematics and statistics support (Environment observation)

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as High Risk

Date of approval:	03 Feb 2023
Project Reference Number:	P140776

Appendix 13 – Author Declaration Form

Article 1

Gilbert, H., Hodds, M., & Lawson, D. (2021). 'Everyone seems to be agreeing at the minute that face-to-face is the way forward': Practitioners' perspectives on post-pandemic mathematics and statistics support. *Teaching Mathematics and its Applications, 40*(4), 296-316. https://doi.org/10.1093/teamat/hrab019

This publication is a presentation of the results from two of the sampling points of the longitudinal study reported in Chapter 4 of this thesis. It is an exploration into practitioners' perspectives on mathematics and statistics support (MSS) during the global COVID-19 pandemic. The paper includes a summary of the key findings from Hodds (2020), presentation of the analysis conducted on the final open-ended question of that survey, report of follow up interviews conducted in January and February 2021, and a discussion reflecting on current practitioner opinion of online MSS support based on the findings.

	First Author *Holly Gilbert*	**Second Author** *Mark Hodds*	**Third Author** *Duncan Lawson*
Contribution	Principal researcher, Conducted interviews, Performed analysis, Section 3, Section 5, Formatting, Editing, Responsible for	Conducted interviews, Section 2, Section 4, Discussion	Abstract, Introduction
		Provided advice, proofread, suggested edits	

The author's own work from Section 3 and Section 5 of this paper have been used within Chapter 4 of this thesis

Article 2

Gilbert, H., Schürmann, M., Liebendörfer, M., Lawson, D., & Hodds, M. (2023). Post-pandemic online mathematics and statistics support: Practitioners' opinions in germany and great britain & ireland. *International Journal of Mathematical Education in Science and Technology, ahead-of-print*(ahead-of-print), 1-26. https://doi.org/10.1080/0020739X.2023.2184282

This publication is a presentation of results from the comparative study completed as the third sampling point in Chapter 4 of this thesis. It looks at the differences between mathematics and statistics support in Germany, and that in Great Britian and Ireland. This article focuses more on the comparison between the two locations, rather than the study being the third sample of a longitudinal study as reported in Chapter 4. Key questions in answer to the research questions discussed at the start of the paper were analysed and reported.

	First Author *Holly Gilbert*	**Second Author** *Mirko Schürmann*	**Third Author** *Michael Liebendörfer*	**Fourth Author** *Duncan Lawson*	**Fifth Author** *Mark Hodds*
Contribution	Created UK questionnaire, Analysis, Results, Creation of infographics, formatting, editing, responsible for submission process	Created Germany questionnaire, Analysis, Research questions, Method and sample	Abstract, Background, COVID-19	Background, COVID-19	Summary and Discussion
		Provided advice, proofread, suggested edits			

The Author's own work from the Results section of this paper has been adapted to be included in Chapter 4 of this thesis