DOCTOR OF PHILOSOPHY

An Investigation of Student Engagement and Non-engagement with Mathematics and Statistics Support Services

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An Investigation of Student Engagement and Non-engagement with Mathematics and Statistics Support Services

By

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Abstract

In the last 30 years, Mathematics and Statistics Support Centres (MSSCs) have been firmly established at universities globally to support students with mathematical or statistical content. Universities regularly measure the effectiveness of their services, reporting that students who engage with mathematics and statistics support (MSS) have increased confidence in mathematics and improved outcomes. However, some students still fail to avail of the support.

At Coventry University, the MSSC, **sigma**, reports a yearly increase in student usage, yet the issue of non-engagement persists, further impacted by the global Covid-19 pandemic. Whilst some research has been conducted around student engagement with MSS, many facets could be researched further, such as how demographic characteristics, constructs like mathematics anxiety (MA), mathematical resilience (MR) and affective reasons impact on engagement. This study aims to explore whether specific factors affect engagement, what reasons students give for using (and not using) MSS, and what recommendations can be made to tackle this issue.

A mixed-methods approach was used. Attendance and demographic data for **sigma** across two academic years, as well as established scales measuring students' MA and MR, were analysed. The effectiveness of an MR intervention was also explored. Qualitative data was gathered through semi-structured interviews and a predominantly open-ended questionnaire. Key findings were used to form recommendations of future practice.

Key and novel findings showed that certain student characteristics significantly influence either whether students engage or not and how many times they visit. Questionnaire findings showed students who engaged had significantly higher MA than non-engagers and that an increase in MA also significantly predicted an increase in engagement. However, qualitative data suggested that whilst high MA may encourage some students to engage, for others, it was a source of fear. Interview findings concretely supported speculation in the literature that some students give "shallow" reasons for non-engagement to avoid revealing their "real" reason. It was further found that students give such reasons to explain their engagement too. It was concluded that there appears to be a strong relationship between MA, student characteristics and engagement, such that, should it be addressed, it may increase engagement with MSS considerably.

For MSS practitioners, the study highlights the need for more effective and affective advertising, with an emphasis on challenging assumptions that the support is remedial by increasing contact with less mathematically confident students, perhaps through embedding the support within their course. Such action is likely to promote usage of MSS by some at-risk students who presently do not engage at all.

Dedication

I dedicate this thesis to my mum, Yasmin Patel. Her sacrifices, love and prayers have helped to bring me to where I am today. I will never be able to adequately share how much she means to me and how much she has inspired me through her faith and actions. She has been more than a mother and father to me, and I hope I will always be someone that makes her proud.

Most of all, I give thanks to the One who has made all this possible and put such people in my life as a means of aid.

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Finally, I would be remiss if I did not again acknowledge the One who has guided and blessed me throughout my journey. My gratefulness knows no bounds.

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List of Publications

Journal Papers

- Gokhool, F, Lawson, D & Hodds, M. (2022), 'Investigating the relationship between mathematics anxiety, mathematical resilience and mathematics support engagement: an analysis of demographic and cohort factors', MSOR Connections, vol. 20, no. 2, pp. 82-93. https://doi.org/10.21100/msor.v20i2.1321
- Gokhool, F., Lawson, D., Hodds, M., and Aslam, F. (2021) Exploring differential engagement with mathematics support from an engineering student focus. Teaching Mathematics and Its Applications. Available from: https://doi.org/10.1093/teamat/hrab033
- Lunat, F. (2020) Engagement with Mathematics and Statistics Support, **sigma** network newsletter, Issue 19. Available from: https://www.**sigma**-network.ac.uk/wp-content/uploads/2020/03/**sigma**-Newsletter-Issue-Spring-2020.pdf

Planned publications

- Gokhool, F. "Affective reasons impacting student engagement with MSS: recommendations for future practice."
- Gokhool, F. "Which student characteristics affect student engagement with MSS?"
- Gokhool, F. "The impact of mathematics anxiety and mathematical resilience on student engagement with MSS."
- Gokhool, F. "Can a mathematical resilience intervention increase MSS engagement?"
- Gokhool, F. "The effect of the Covid-19 pandemic on student engagement with MSS: a mixed-methods study."

Conference Presentations

- Presentation at: CETL-MSOR conference (Abertay University) – 1st-2nd September 2022, “Student engagement with mathematics and statistics support: students’ perspective”
- Presentation at: 3rd International Conference Developing Mathematical Resilience (Open University) – 1st & 2nd July 2022, “The use of a mathematical resilience intervention to increase student engagement with mathematics and statistics support”
- Presentation at: CETL-MSOR conference (Coventry University) – 2nd-3rd September 2021, “An investigation of the impact of mathematics anxiety on student engagement with mathematics and statistics support”
- Invited Presentation at INSTEAD VII (Innovative teaching methodologies for math courses on engineering degrees) conference (University of Porto) – 5th July 2021
- Paper presentation at SEFI SIG in mathematics seminar (University of Norway) – 17th-18th June 2021
- Presentation at GLEA showcase event (Coventry University) – 4th November 2020

Planned presentation

- Presentation at: **sigma** showcase (Coventry University) - 31st March 2023, “How does mathematics anxiety affect student engagement with MSS?”

1 Introduction

Engagement with Mathematics and Statistics Support (MSS) services has been linked to better student outcomes, higher retention rates and increased mathematical confidence (Carroll & Gill, 2012). Therefore, this thesis investigates factors affecting student engagement and non-engagement with MSS. Student explanations for their engagement (or lack thereof) with MSS are examined. In addition, the impact on the engagement of general demographic characteristics (such as age, gender and ethnicity) is explored with a particular focus on mathematics anxiety (MA) and mathematical resilience (MR). The effectiveness of an MR intervention in increasing engagement with MSS will also be discussed. This chapter will share an overview of the study within the context of research in the field by explaining the background of the concerns around MSS and student engagement before outlining the research questions this study aimed to answer. The section will conclude by providing a brief description of the forthcoming chapters.

1.1 Background

The mathematical under-preparedness of incoming undergraduate students has been of rising concern for many years. This "mathematics problem" has been documented across multiple reports (London Mathematical Society, 1995; Hawkes & Savage, 2000). Many STEM courses have, because of the mathematics problem, suffered from poor retention and high failure rates (National Audit Office report, 2007) with a severe knock-on effect on the mathematical competency of society (ACME, 2011). The government acknowledged the detrimental effects of the mathematics problem on society and working people, with recent suggestions by the Prime Minister even discussing the continuation of mathematics studies until the age of 18 for English students, where it is currently only mandated until the age of 16 (Scott, 2023).

The problem has only been exacerbated by the explosion in data availability that has led to the increasing quantification of many disciplines, such as biosciences (British Academy, 2012). With the mathematics problem putting pressure on the working population, many interventions have been set in place by the government and others to tackle this. One such measure is the arrangement of a national inquiry which led to the Smith report (Smith, 2004). This report reported that, for the short-term at least, universities would have to "accommodate to" the students they were getting from the school/college system. The introduction of MSS by universities was one way to accommodate to these students. This thesis focuses on the provision of MSS in a university in the UK. However, it is worth noting that the "mathematics problem" is not a phenomenon confined to the UK. There is extensive literature discussing similar issues in Australia (for example, Matthews et al., 2012), Ireland (for example, Gill et al., 2010) and across Europe (Alpers, 2008). It is no coincidence that most universities in Australia and Ireland have MSS provision (MacGilivray, 2009; Cronin et al, 2016). In Germany, a growing number of institutions are starting to provide such support (Schürmann et al., 2021). The support is universally defined to be "a facility offered to students (not necessarily of mathematics) which is in addition to their regular programmes of teaching through lectures, tutorials, seminars, problems classes, personal tutorials, etc." (Lawson et al., 2003, p.9). 88 out of 103 institutions now provide some form of MSS in England and Wales (Grove et al., 2020), with Cronin et al. (2016), Ahmed et al. (2018) and MacGillivray (2009) detailing the extent of the provision in Ireland, Scotland, and Australia respectively.

Studies have also shown that engagement with MSS increases students' confidence in mathematics and affects retention (Carroll & Gill, 2012). However, whilst MSS may contribute to mitigating the mathematics problem, many students fail to take advantage of the available support, particularly students at risk of failing their course (O'Sullivan et al., 2014; Symonds et al., 2008). Whilst the principal reasons students give for their lack of engagement are structural (e.g., "I didn't know it existed," "the times didn't suit"), both of which were options in a fixed response questionnaire (O'Sullivan et al., 2014), it has been suggested that this may be a mask for affective reasons like fear, anxiety, or embarrassment (Symonds et al., 2008).

A small body of literature investigates engagement with MSS among different demographic groups. However, the current literature has generally focused on the impact of a single, isolated demographic factor (Ní Fhloinn et al., 2016) or occasionally two factors (Dzator & Dzator, 2020), with only Edwards and Carroll (2018) investigating more than two. These studies have focused primarily on age and gender as factors that may impact engagement with MSS. There has been little or no work investigating either disability or ethnicity as a factor, despite the current focus on both aspects and engagement in higher education as a whole (Office for Students, 2020).

Another factor that has not previously been explored concerning student engagement with MSS is mathematics anxiety (MA), which is a feeling of apprehension about mathematics that affects the ability to learn mathematics effectively. This widely acknowledged condition impacts learners' engagement with and success in mathematics (Dowker et al., 2016). While levels of MA can inhibit student engagement with mathematics, it is yet to be determined whether this also extends to engagement with MSS. A relatively new construct known as mathematical resilience (MR) is defined as overcoming hurdles to effectively learn mathematics (Johnston-Wilder and Lee, 2010b), with one such limitation, for some learners being MA. MR may alleviate the effects of MA by giving students strategies to combat their instinctive adverse reactions to mathematics.

This thesis will therefore investigate the gaps in this field of research in relation to student engagement with MSS, particularly with **sigma** at Coventry University.

1.2 Research questions

The research undertaken in this study is centred on answering the following research questions:

RQ1) How do student characteristics affect student engagement with MSS?

RQ2) What effect, if any, do MA and MR have on student engagement with MSS?

RQ3) What is the effect, if any, of developing students' levels of MR on their engagement with MSS?

RQ4) How do students explain their level of engagement with MSS?

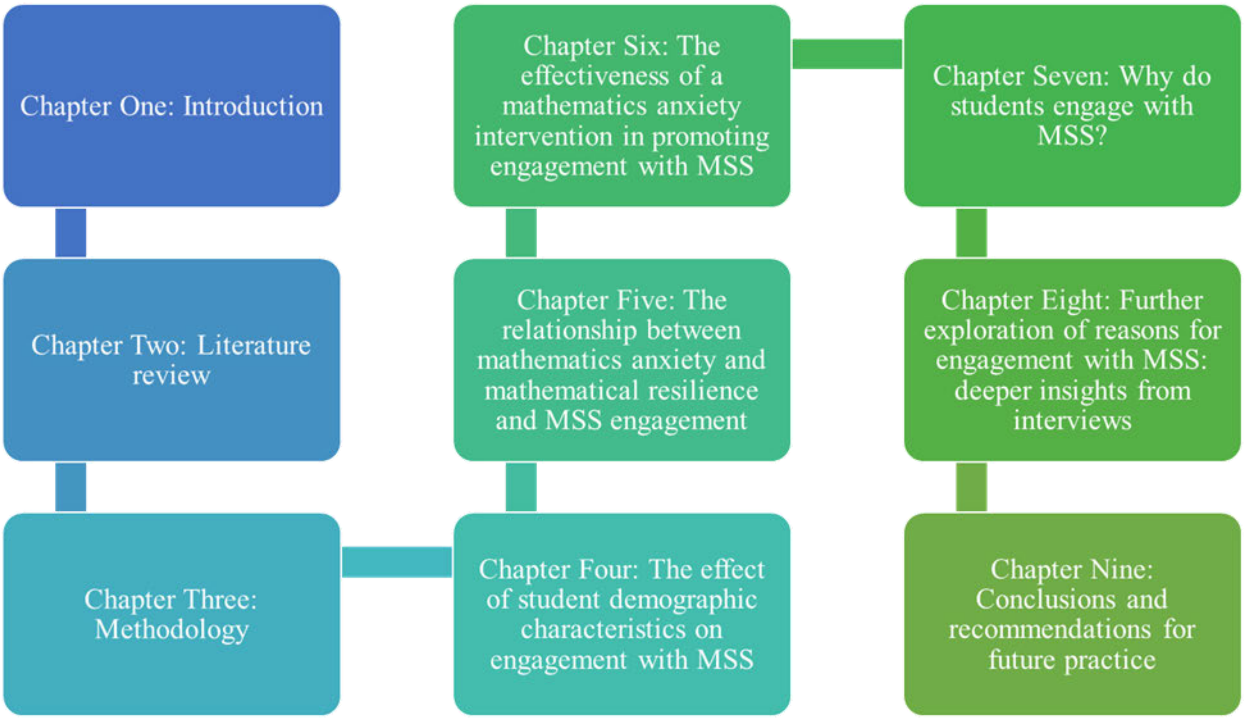
This research is significant as not only does it provide a novel contribution to the field by answering posed questions in the existing literature about why students do not engage with MSS, but it also gives some initial insight into the interrelatedness of demographic factors and their impact on engagement with MSS, as well as what role MA and MR play in relation to this. Identifying engagement patterns across student groups provides an understanding of who may benefit from targeted advertising and interventions.

1.3 Outline of thesis

This chapter has provided a brief overview of the research study and located it among concerns around the mathematical preparedness of undergraduates and increasing engagement with MSS, particularly among groups of students that need the support. The structure of the thesis, as guided by the research questions, is presented in Figure 1.1.

Figure 1.1

Flowchart outlining the structure of the thesis



Chapter 2 provides a more in-depth background of the field in which this research is located by reviewing relevant literature. The "mathematics problem" is first described to justify the necessity of MSS in Higher Education. A brief background is given on student engagement, followed by a description of MSS centres, including their general format and growth over the years. The impact of the Covid-19 pandemic on student engagement in education and with MSS is then detailed, followed by a brief insight into the constructs of MA and MR. The chapter ends with the importance of researching the relationship between ethnicity and engagement with MSS, which has previously not been explored.

The methodology used in this study is shared in Chapter 3 and includes a fundamental diagram of the overall structure of the research. Both qualitative and quantitative research methods are compared before explaining mixed methods research and the reasoning behind using mixed methods. Information on data collection methods is then shared before detailing which methods were used in this study, how they were used and why this was appropriate.

Chapters 4 to 8 are results chapters, separated by the research questions each dataset used to answer. Chapter 4 deals with the secondary data relating to **sigma** usage and student demographics from the academic years of 2018/19 and 2020/21 to provide insight into the impact of the pandemic on engagement with the centre and which students are using the support. Chapter 5 shares findings from an MA and MR questionnaire, which are well-established scales in the field. The results are explored in relation to engagement with MSS again and with the demographic characteristics discussed in Chapter 4 for a thorough analysis. An MR intervention delivered to students at CU is described in Chapter 6, along with an evaluation of its success. Chapters 7 and 8 deal with predominantly qualitative data collected from open-ended questions on an engagement questionnaire and semi-structured interviews to provide context and meaning to the results described in Chapters 4, 5, and 6. Both the interviews and questionnaire asked students to share their reasoning for their engagement or lack thereof with **sigma** whilst also asking other related questions about MA, past experience with mathematics and any improvements that could be made to the support provided.

Chapter 9 combines the findings from the research thus far whilst commenting on whether the different results support each other and how they relate to other research in the field. Recommendations for future practice are suggested, and future work that may be undertaken, thus providing a framework for engagement with MSS.

2 Literature review

2.1 Introduction

This chapter provides a review of the literature covering several issues relating to engagement with mathematics and statistics support (MSS). It begins in the next section with a discussion of the “Mathematics Problem”; this phrase sprang from the title of a key report published in 1995 by a group of learned societies and professional bodies entitled ‘Tackling the Mathematics Problem’ (London Mathematical Society, 1995). In UK higher education and increasingly worldwide, the phrase the Mathematics Problem has come to mean the under-preparedness of many incoming students for the mathematical demands of their course of study. The title of this 1995 report has been picked up in subsequent reports by other national bodies, such as ‘Measuring the Mathematics Problem’ (Hawkes & Savage, 2000) published by the Engineering Council and ‘Solving the Mathematics Problem’ (Norris, 2012) published by the Royal Society of Arts and Manufacture. A national inquiry into post-14 mathematics education found, “HE has little choice but to accommodate to students emerging from the current GCE process” (Smith, 2004, p. 95). These reports and other important literature relating to the Mathematics Problem are discussed in Section 2.2.

One such response by many universities in the UK to help mitigate, in part, the Mathematics Problem has been the introduction of some form of mathematics and statistics support (MSS) provision. MSS has been defined by Lawson et al. (2003, p.9) as “a facility offered to students (not necessarily of mathematics) which is in addition to their regular programmes of teaching through lectures, tutorials, seminars, problems classes, personal tutorials, etc.”. The nature, extent and development of MSS is reviewed in Section 2.3, not only in the UK but internationally, including the impact that the coronavirus pandemic had on these provisions.

Since MSS is typically a voluntary provision that students opt into (i.e., it is in addition to their regular teaching), some students choose to engage with what is offered whilst others do not, despite numerous benefits of engaging being identified (see, for example, Dzator & Dzator, 2020). The issue of student engagement has been considered by several researchers, including O’Sullivan et al. (2014) and Symonds et al. (2008). Literature relating to student engagement more generally and with MSS more specifically is considered in Section 2.4.

Many factors may influence student engagement with MSS. One such factor is mathematics anxiety (MA). MA is a “feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p. 551). High MA in students is related to poor mathematical and academic performance, and, since MA often also leads to procrastination and avoidance of mathematics (Dowker et al., 2016), it is likely that high MA also hinders students from seeking support. The construct of MA as well as its relationship with engagement is further detailed in Section 2.5.

A proposed method of mitigating the damaging effects of MA is by building mathematical resilience (MR), a positive affective stance to mathematics (Johnston-Wilder & Lee, 2010a). The construct is made up of three dimensions: struggle, growth and value (Kooken et al., 2013), with the current discussion surrounding the addition of a fourth construct, community (Lee & Johnston-Wilder, 2017). Numerous studies have investigated the prevalence of MA amongst different demographic groups such as age or gender, but these variables have never been investigated together within the same study or mapped alongside MR levels on a large scale in university students. Further discussion of the benefits of building MR for students with high MA can be found in Section 2.6.

Demographic engagement relating to MSS services again mirrors this; studies, usually focusing on an individual demographic factor such as age or gender, have been conducted (e.g. Dzator and Dzator, 2020; Ní Fhloinn et al., 2016). Ethnicity is also of particular interest because of the significant difference in degree attainment between white and ethnically diverse students. The causes for this gap are complex; however, the outcomes for ethnically diverse students are consistently lower than that of white students, even once factors such as entry grades are controlled for (Smith, 2019). If a gap in engagement between white and ethnically diverse students is found to exist in the MSS sector, tailored interventions could be delivered to remedy this. Literature relating to the "attainment gap" are discussed in Section 2.7.

This literature review will therefore begin by providing an overview of the issues related to the fall in mathematical preparedness of undergraduates, followed by the extent and success of MSS that has been created in response to this. It will also detail some reasons attributed to the low engagement of certain students, and a method designed to tackle high MA in students. Finally, an overview of the ethnicity attainment gap will be provided. The topics covered in the literature review are outlined in Figure 2.1.

Figure 2.1

The flow of the key topics covered in the literature review

2.2 The Mathematics Problem

The mathematical preparedness of new undergraduates has been of rising concern, particularly for those pursuing Science, Technology, Engineering and Mathematics (STEM) degrees, for many years. This issue first became known in the late 1980s, when high dropout rates and failure rates amongst engineering students caught the attention of Higher Education Institutions (HEIs). HEIs initially provided ad hoc localised support specific to their universities to try to resolve this (Lawson et al., 2020). From the mid-1990s onwards, several articles and reports highlighting the widespread problem were published. In 1995, the London Mathematical Society (LMS) produced a key report, which stressed the problem and coined the term “the mathematics problem”; this report led to others (e.g. Sutherland & Pozzi, 1995; Hawkes & Savage, 2000; Lawson, 2000), particularly surrounding engineering students, which found that the mathematical competency of these students was weaker than it had been for the previous ten years (Sutherland & Pozzi, 1995).

Claims were further made regarding the inadequacy of A levels in preparing students for the mathematical content of their courses (Hawkes & Savage, 2000). Additionally, Lawson (2000) and Lawson (2003) found those achieving a Mathematics A level grade C in 1997 achieved the same score on a diagnostic test at the start of their course as those that received a grade N (narrow fail) in 1991. Those with an entry grade B in 2001 performed similarly to those receiving a grade N in 1991, providing quantitative evidence for the decreasing mathematical fluency of incoming undergraduate students. This quantitative evidence further strengthened the messages of the reports. In response, the Government set up a national inquiry into post-14 mathematics education. One of the findings of this inquiry was that "HE has little choice but to accommodate to students emerging from the current GCE process" (Smith, 2004, p. 95).

Other factors compounded the mathematics problem: for example, the establishing of the widening participation agenda, a policy to increase the number of those entering university from underrepresented backgrounds (Thomas, 2005). Since the focus shifted to making the university student demographic more closely represent the UK's more diverse population demographic, universities began to accept more students that had not achieved what had previously been the entry requirements for their chosen courses. As mentioned previously, there was evidence that even students with higher grades had less competency in key areas and accepting students with lower grades exacerbated the problem.

This problem is not unique to those studying mathematically based degrees such as those in the STEM disciplines. In recent years, most subjects have become more quantitative; more disciplines require a strong foundation in mathematics and statistics (British Academy, 2012). Research shows that many students do not have the level of mathematics competency required to succeed on their course, and this trend is notably prevalent in, but not exclusive to, the biosciences and social sciences. As Lawson et al. (2020, p. 3) explain: "In the early 1990s, the users of mathematics support were mainly students of engineering and the physical sciences. However, technological, and scientific advances over the last 30 years have resulted in many subjects such as the biosciences and social sciences becoming much more reliant on mathematical modelling and statistical analysis (see, for example, BBSRC, 2010; British Academy, 2012). These changes in practice in several disciplines have produced a demand for support, particularly in statistics, from groups of students who previously would not have sought such support."

A study by the Advisory Committee on Mathematics Education (ACME) estimated that around 330,000 students per year enter higher education in the UK to study courses where they would benefit from having studied some mathematics post-16, but in reality fewer than 125,000 have done so (ACME, 2011). Consequentially, those responsible for designing university courses, having had to take this into consideration, cannot include the level of mathematics in their respective courses that is now necessary. Although solving this problem is clearly important for the mathematical fluency of the working population, and thus, the economy, this is also of considerable concern to universities because of its relation to low retention and low progression rates (National Audit Office, 2007; Crosthwaite & Kavanagh, 2012).

Additionally, with the world of work requiring more quantitative and data processing and reporting skills, employers favour more numerically competent graduates for many positions (Wood, 2010). To test the numerical skills of potential employees, numerical reasoning tests are becoming the norm for many recruitment tests, thus incentivising the development of these skills (Wolf & Jenkins, 2002). If a student wishes to succeed in the workplace, it is almost incumbent on them to hone their numerical skills. In several disciplines, such honing of numerical skills is unlikely to come through the standard curriculum and students may need to engage with additional learning opportunities, such as those provided by MSS, to enhance their skills. A joint statement from the Royal Society and British Academy asserted that "There is a substantial unmet demand from UK employers for quantitatively skilled people from all disciplines – arts, humanities, sciences and social sciences" (The Royal Sciences & The British Academy, 2022, p. 1).

It is not only students that are of concern; questions have been raised regarding the lack of confidence in academic staff to teach the level of mathematics now required for the current workforce (British Academy, 2012; Norris, 2012). The British Academy (2012, p.4) states, "Another reason for the poor skills of undergraduates is the dearth of academic staff able to teach quantitative methods … as few as one in ten university social science lecturers have the skills necessary to teach a basic quantitative methods course". There is therefore a fear of this becoming a cyclical issue, where current staff avoid teaching mathematical content due to their lack of confidence, which results in their students never learning the necessary numerical skills to build their own mathematical competence and confidence. In turn, this may contribute to the lack of mathematical competency in the next generation of lecturers, since they will be drawn from the current student cohort, and so on.

Therefore, Smith's previously cited conclusion is still applicable, and universities need to continue to accommodate to students emerging from the current school system. A major way of doing so is through the use of mathematics and statistics support (MSS).

2.3 Student Engagement in Education

Substantial focus has been placed on raising student engagement levels generally since this has been linked to better attainment, higher retention rates and aiding students' positive development (Appleton et al., 2008; Appleton et al., 2006). Though its importance is clear, there is a lack of depth in the knowledge surrounding this construct. A plethora of terms have been used to define engagement and what exactly it entails (Alrashidi et al., 2016). However, despite the varying terms, there are several constructs that commonly underlie these definitions. This reinforces the idea that, though there has been much variation in the interpretation of the term, engagement is a broadly proactive term pertaining to a student's integration with their educational institution. It also considers their commitment to studying, the quality of their interaction with their educational institution and extra-curricular activities, such as participation in sports. Hu and Kuh (2002, p.3) define student engagement to be "the quality of effort students themselves devote to educationally purposeful activities that contribute directly to desired outcomes".

As evidenced by the difficulties in creating an agreed definition, student engagement is multidimensional. Researchers have either adopted a two (Audas & Willms, 2001), three (Fredricks et al., 2004; Schaufeli et al., 2002) or four-dimensional explanation (Reeve & Tseng, 2011) for engagement. The two-part model typically consists of a behavioural dimension and either a psychological or emotional dimension. Schaufeli et al.'s three dimensions are vigour (resilience), absorption (engrossment in tasks) and dedication (to learning) whilst Fredricks et al.'s dimensions are behavioural, cognitive and emotional (affective). Both models are widely used; however, the Fredricks' model is more relevant in this study because it explicitly includes relationship with peers and staff, whereas Shaufeli's model is primarily about a student's psychological relationship with their studies. The dimension of vigour appears to overlap with cognitive engagement, whilst absorption and dedication is similar to behavioural engagement. To note, although Fredricks' model was developed in schools, the elements it identifies are applicable in HE too. According to Fredricks, engagement can be defined as having three dimensions: behavioural, cognitive, and emotional.

It is clear upon observation that, to an extent, the three dimensions share a relationship, as each component can affect another. In this model, (lack of) behavioural engagement is observable and can serve as an early indicator of dropout rates. This is seen by observing a student's positive interactions in a lecture, seminar, and workshop, such as contributing to seminar discussion, asking questions, focusing, and generally expending effort. Cognitive engagement relates to a student's resilience when working on difficult tasks, their willingness to understand concepts wholly, as opposed to using memorisation to perform well, and their ability to self-regulate. To summarise, it is about a student's willingness to learn at a deep level (Trigwell & Prosser, 1991). Emotional engagement refers to a student's responses to teachers, peers, and school (or, in a HE setting, to lecturers/tutors, peers and the university). It is observable via the identification of a student's positive attitude in university and a lack of identifiable boredom and anxiety. Students with a strong emotional engagement also feel supported by their lecturers and peers and have a sense of 'belonging' at the university (Thomas, 2012).

It is apparent that this model steers focus onto a student's resilience in the face of challenging scenarios, and a positive approach to learning. Several studies (Chase et al., 2014; Mo & Singh 2008) highlight the positive contribution of these three types of engagement on students' results, either individually, or after combining them. Collectively, they have shown that an increase in engagement correlates with an increase in grades. Fredricks et al. (2016), after a paper aiming to create a survey on engagement, decided that another social dimension may be necessary, in line with what other researchers had suggested (e.g., Rimm-Kaufman et al., 2014; Finn & Zimmer, 2012) when considering the important role social interactions play. Social-behavioural indicators would include working with peers, whilst social-cognitive behaviours would consider how students could teach one another, add to others' ideas and understand different perspectives and social-emotional indicators would include students feeling involved with their group and enjoying group tasks. However, Fredricks et al. (2016) created a separate scale to measure social engagement, rather than being a sub-dimension of the existing three. In a continuation of this research, Wang et al. (2016) found that adding a social dimension to the scale that aimed to measure mathematics and science engagement supported social engagement as being conceptually related to the other three dimensions, but also represented a unique construct.

It is worth noting that, though not as widely acknowledged, agentic engagement (Reeve & Tseng, 2011), which significantly differs from the previously mentioned dimensions, involves a student directly influencing the teaching they receive as a means to enrich the learning process. It is a student's constructive contribution toward the flow of the instruction he receives (Alrashidi et al., 2016). With a relationship found between a student's intrinsic motivation and engagement (Saeed & Zyngier, 2012) developing a student's agency may be key to increasing their overall engagement and, thus, their attainment. The development of opportunities for agentic engagement is something that may be considered as a way of increasing engagement with MSS.

Wang and Degol (2014) stresses the importance of identifying the distinction between motivation and engagement, where motivation is 'the driving force behind the successful completion of a goal or academic task', which, in turn, creates 'engagement', a medium for achievement. Motives for studying are dependent on several factors, and thus each student's desire to study will vary vastly. Hence, it is imperative that interventions are tailored towards the requirements of the student, as an overgeneralised intervention may have little to no effect on the target demographic. As previously discussed, engagement is of a multifaceted nature, and thus, there are several avenues to explore the potential of increasing engagement. In addition to this, the validity of the construct of engagement has been brought into question several times, with some studies assessing and confirming the validity of the psychological and cognitive dimensions (Appleton et al., 2006), whilst others highlight the weak associations between academic success and the National Survey of Student Engagement (NSSE) benchmarks (Payne et al., 2005).

The survey instruments used to measure engagement may not be able to fully measure all aspects of this complex construct. There could be differences due to the nature or structure of the institution or to the subject being studied. Not all survey items have the same relevance in all disciplines. For example, survey items about reading outside lectures may have less relevance for mathematics students than they do for history students. It has been suggested that this lack of consideration for relevant measures of engagement has led to some studies concluding that it is more challenging for mathematics and science students to achieve higher levels of engagement than Arts and Humanities students (Ahlfeldt et al., 2005). Therefore, it is of paramount importance that when measuring student engagement with mathematics, and by extension with mathematics support, multiple methods should be utilised to gain deeper insight than may otherwise have been achieved through the delivery of a single survey.

There is strong evidence to support the impact of student engagement, in particular, the emotional, cognitive, and behavioural dimensions of engagement, on student performance (Dogan, 2015; Reeve & Lee, 2014; Chase et al., 2014). Studies have both established that the construct is malleable and highlighted methods, based on the aforementioned dimensions, through which teachers can improve student engagement; some tried-and-tested interventions can be found in The Handbook of Student Engagement Interventions: Working with Disengaged Students (Fredricks et al., 2019). Some key points that teachers must always remember when trying to promote engagement can be found in Zepke and Leach's (2010) research. One such method highlights the importance that supportive teachers have on engagement; for example, Reason et al.'s (2006) research found that first-year students who felt academically supported showed a significant improvement in their academic performance. Another paper spoke of the importance of students from diverse backgrounds feeling welcomed by the culture of the institution (Harper et al., 2004). Building students' self-belief is also key as when learners believed they had the capacity to finish a task, their engagement grows (Llorens et al., 2007). This is further supported by Abu-Hilal and Al Abed (2019, p.258) who state, "If teachers and educators want their students to be engaged in learning mathematics, they should equip them with high confidence expectations". This research can also be utilised in MSS, where engagement is of growing concern. The importance of teaching practice on student engagement is clear and to further support this idea, specific research has been conducted into the role tutoring plays in facilitating student engagement (Faroa, 2017). Additionally, Johnston-Wilder and co-workers (Johnston-Wilder et al., 2013; Johnston-Wilder et al., 2014b) have shown that training teachers how to reduce MA could increase engagement with mathematics. Mathematics Support Tutors could receive this same training, which could translate into more engagement with MSS. It is also important to take into consideration that students seeking support are seen as individuals and not as 'a member of a stereotyped, homogenous mass' (Bryson & Hand, 2008).

2.4 Mathematics and Statistics Support

2.4.1 What is MSS?

Lawson et al., (2003, p.9) have defined mathematics support as "a facility offered to students (not necessarily of mathematics) which is in addition to their regular programme of teaching through lectures, tutorials, seminars, problems classes, personal tutorials, etc." In its early days in the 1990s, mathematics support provision was described as a "cottage industry" (Kyle, 2010) and regarded as a "Cinderella service" (Grove et al., 2018a). However, it has now evolved to being an embedded part of the student experience in many universities in the UK. A recent survey reported that 88 out of 103 institutions have some mathematics and statistics support provision (Grove et al., 2020). Not only is there widespread provision of MSS in universities throughout the UK, but many institutions also now view their MSS as a clear point of strength. Croft et al. (2022) analysed three types of documents, demonstrating excellence of education in their institutions, submitted by 101 UK universities to higher education regulators. They found that 63 of these universities included descriptions and analysis of their MSS as evidence of their excellence.

The nature of institutional provision of MSS can vary (see Marr and Grove (2010) for more information), with the most common type of provision being a Mathematics and Statistics Support Centre (MSSC). Before the pandemic, this would almost always be a physical location. Along with providing a space for students to work, MSSCs hold resources such as books and topic-specific handouts. MSSCs are staffed by tutors who will work one-to-one with students or occasionally, as groups. This one-to-one support is available either through a drop-in service or by pre-booking appointments (Lawson et al., 2020). An appointment usually gives students more time with the staff member, whereas the drop-in service, depending on how many other students are waiting to be seen, is more suited for those with quick enquiries or looking to be directed to any resources on hand. Many institutions also offer workshops on important mathematics/statistics knowledge and skills (such as SPSS) where students who all need assistance on the same topic can receive help simultaneously.

The first systematic study of MSS provision was carried out in 2001 and reported in two papers (Lawson et al., 2001a; Lawson et al., 2001b). This led to the publication of the guide Good Practice in the Provision of Mathematics Support (Lawson, et al., 2003) from which the definition of mathematics support cited above is taken. In this study, 58 student users of MSS were interviewed at seven institutions. It was reported that "It was clear from the interviews with student users that the one-to-one help was the most highly valued part of every support centre" (Lawson et al., 2003, p. 12). This comment is expanded on in Lawson et al. (2002) where the value of one-to-one assistance is particularly attributed to the nature of the tutor: "one-to-one assistance from a sympathetic tutor who is willing to take time to explain things" (p. 26). Other work has similarly identified the importance of the role of the tutor (e.g., Grove & Croft, 2019).

As mentioned above, from all types of provision offered by MSSCs, one-to-one support is considered the most useful by students (Lawson et al., 2003). The success of the one-to-one help may largely be attributed to the staff appointed to take on the role of Mathematics Support Tutors (MSTs). Grove et al. (2019) highlights the importance of staff that are able to build the mathematical confidence of students and also that students are successfully building their mathematical confidence through their engagement with MSSCs. MSS services have tried to achieve this by appointing a mixture of academic staff, postgraduate students, final-year undergraduate students and/or separate staff that are dedicated to their role as tutors (Croft & Grove, 2016).

Staffing varies from institution to institution with a mixture of dedicated MSS staff, academic staff from the mathematics department, postgraduates and final year undergraduates being used throughout the sector (Grove et al., 2018c; Johns et al. 2021). Students have commented on the benefits of having postgraduate students take on the role of a Mathematics Support Tutor (MST) and it is also noted that having this familiarity between student and tutor may also make seeking support from postgraduate students "less scary" (Grove et al., 2020b, p. 662). Both knowledge of material and being approachable are essential to the role of a successful tutor.

Several publications explore the nature of MSS provision (for example, Lawson et al., 2003, MacGillivray & Croft, 2011; Marr & Grove. 2010), with many outlining the importance of providing a "welcoming, supportive and non-threatening" environment to "assist all students" (Mac an Bhaird & Lawson, 2012, p.10). The necessity of such an ethos is highlighted in Delderfield and McHattie (2018) where, it was found upon analysing observations of 4 sessions with a tutor that fostering such an environment was conducive to student learning. It also found that a supportive relationship with the tutor is key, with focus placed specifically on empathy and unconditional positive regard. Furthermore, a survey of 82 MSSC users from 12 HEIs across the UK and Ireland by Fitzmaurice and Mac an Bhaird (2021) showed that when students had to give their perspective on the best practice of tutors, 17 of 45 responses were about the approachability of tutors, another 17 were around "listening, patience or open-mindedness", and 11 were about tutors being "encouraging". The importance of the staff is evident across the literature.

2.4.2 Who is MSS for?

As discussed in Section 2.1, the Mathematics Problem was originally identified in relation to engineering and physical sciences students. As such, MSS originally targeted such students. For example, the BP Mathematics Centre at Coventry University was established with funding from the BP Engineering Education Fund (Lawson, 2021). The use of MSS has now evolved to have many non-STEM users as a result of the quantification of many disciplines and the widening participation agenda, and as such, MSSCs have developed their provision to account for this.

Some universities offer MSS to any member (students at every level including postgraduate researchers and staff) of the university. Others limit their provision to only foundation and first-year students, in some cases because of the amount of staffing resource available and in other cases to avoid the monopolisation of the centre by those who may require very specialised help, such as Masters and PhD students (Cronin, 2016).

Mathematics students often make extensive use of MSS. For example, Lawson (2015) gives data from Loughborough University showing that in 2011/12, 26% of the students who attended the drop-in provision were mathematics students and they accounted for 48% of the visits. As a result of this disproportionate usage, some institutions tailored MSS provision to exclude mathematics students, since they have been reported as "colonising" the MSSC (Solomon et al., 2010; MacGillivray, 2009). This can have the negative effect of deterring other students, perhaps from non-mathematics backgrounds, from accessing the support. However, preventing some students from using the centre can have the unfortunate side effect of undermining the ethos of the centre, which is to create a safe, supportive space to offer informal support outside of lectures (Lawson et al., 2003).

In principle, MSS can be needed by students in every level from foundation and 1st year through to masters and PhD and even staff. At some institutions this is embraced whilst at others, resource limitations force them to restrict who is permitted to engage with MSS to those in the early years of their studies (Cronin, 2016). Whilst the original motivation for providing MSS at many institutions was to support at-risk students, there has been a marked shift away from this with the support now there to support all students.

2.4.3 Effectiveness and Impact

With the need for support only increasing, there has been a concerted effort globally to review, improve and share effective practices in delivering MSS. The establishment of the **sigma** network, which anyone with a professional interest in MSS can join (Croft et al., 2015), means institutions work collaboratively and share effective resources/techniques, as well as any research conducted on improving the provision of MSS.

Studies have been completed to evaluate the effectiveness of MSS to great success; a literature review of MSS evaluation studies is given by Matthews et al. (2013), with further updates in Lawson et al. (2020). Both quantitative and qualitative data have been analysed to determine the effectiveness of MSS. Initially these studies focused on usage data of the centres and student feedback sheets, the latter of which are overwhelmingly positive. However, Croft (2009) rightly points out student comments are rarely negative since students appreciate that personal support is available at all. The pass rates of at-risk students as well as the likelihood of students completing their course after engaging with MSS have also been measured. The measurement of success between centres may also differ; for example, in Marr (2010), one aim that is reported in some institutions is to have a low number of average visits per student as this indicates that the student has received the help they required in as little time as possible, whilst in other institutions regular return visits are seen as a sign of success. It is clear to see that where possible, universities have measured the success of their centres in various ways, which can help direct future funding and inform practice.

Several studies have also evaluated the impact of MSS on the mathematical confidence of students and on retention rates. Dzator and Dzator (2020) ran a study with 62 students that had engaged with MSS at Central Queensland University. They completed a questionnaire (adapted from Carroll & Gill, 2012) about attitudes on mathematics and statistics and opinions on MSS. It was found that MSS increases the mathematical confidence of mature students, as well as improving their study habits and raising their opinion of mathematics and statistics. In their own study, Carroll and Gill (2012) state that the students perceived 'improving their confidence and comfort' as a key aspect of the mathematics support they valued, as well as the teaching styles used by MSTs in comparison to the teaching styles of lecturers. Students also reported that their MSSC had some influence on them continuing with their mathematics studies; in Dzator and Dzator (2020) over half of students stated that using MSS helped influence their decision to continue with their undergraduate studies. Additionally, other studies, such as Lawson et al. (2001), Mac an Bhaird et al. (2009), and Pell and Croft (2008) have mirrored these findings.

The largest systematic study of MSS to date was carried out by O'Sullivan and his co-workers (O'Sullivan et al., 2014). This study investigated MSS across the island of Ireland (i.e., Northern Ireland and the Republic of Ireland). It used a common questionnaire to gather data from 9 institutions and had 1633 first year service mathematics participants. This is the most extensive data set relating to MSS that has been analysed. 36% of the population had engaged with mathematics learning support (MLS) services. For those that had not engaged, the main reason given for their lack of engagement was help not being required or times not being suitable. When asked what would encourage students to use the support, it was the mathematically weaker students that were more likely to give comments about the structures of MLS. Almost two-thirds of students who had considered dropping out of their course due to difficulty with the mathematical content stated that "availing of MLS had a positive impact on their retention of their course" (p.11). It was also found that MLS was not viewed only as a remedial support, but rather was accessed by students from across the achievement spectrum.

However, despite the unmistakable evidence of the success of MSS in the study of O'Sullivan et al. (2014), there are also some concerning findings. It was found that overall, around one-third of students had engaged with MLS, one-third did not engage and gave reasons around not needing support, and, crucially, around one-third of students did not engage but may have needed to (these students will be referred to as at-risk students). Thus, increasing student engagement, particularly of at-risk students, is key. At-risk students are those that are perhaps more likely to fail their course, and so could potentially benefit from engaging with MSS. Mac an Bhaird et al. (2013) have identified several factors contributing to student non-engagement with MSS, such as fear of embarrassment and fear of showing ineptitude, but the more common reasons given by students are related to the structures of MSS, such as being unaware of the availability of MSS or where such a service was available. Symonds et al. (2008) adopted a mixed-methods approach, holding on-the-spot interviews and delivering questionnaires to investigate student engagement. This study received similar answers related to the structure of

MSS. It was suggested that these answers may be 'excuses' to hide the students' true reasons for non-engagement though no evidence was provided to verify the suggestion. O'Sullivan et al. (2014) also report structural reasons as being those most commonly given by non-users. However, it should be noted that they were using multiple fixed-response questions in their questionnaire which presented these structural options to the students and may therefore have "seeded" them as responses. Interviews and focus groups are seen as giving more in-depth answers (Cohen et al., 2002) and, as such, studies using these methods have a better chance of identifying more affective reasons such as embarrassment. One such study found that fear was the dominant factor in dissuading them from attending (Grehan et al., 2010). This study highlighted how the fear of students had many causes, with some fearing the unknown and others fearing being singled out. However, the sample size was relatively small and singular, with seven participants that were all first-year mathematics students. Interviewing students with a more varied background may reveal different findings.

2.4.4 Demographic engagement

In order to offer all students equal opportunities in accessing support, researchers have investigated engagement with MSS in relation to non-traditional entrants to HEIs.

Breen et al. (2015) used mixed-methods research to gain insight into the engagement and non-engagement of mature students with MSS at an Irish university. Focus groups highlighted their reasons for engagement, namely, motivation, the nature of mathematics, the life experiences of mature students, the non-judgemental nature of MSS and intrinsic motivation to gain knowledge rather than just passing exams. Reasons for non-engagement comprised of claims they did not need support, structural reasons such as times not suiting, and having recently attended a course which meant it had not been several years for them since they had last studied (having a large time-gap in their mathematical education was regarded as a motivation for engagement with MSS). Mature students' felt that traditional students were better prepared for course material and that, due to the optional nature of MSS, traditional students may not engage. Mature students also claimed that traditional students may not be as comfortable asking for help, aside from asking their peers.

The quantitative analysis in Breen's study focused on determining the effect of engagement on student grades, with non-significant results being returned. Whilst these focus groups provided much cause for discussion, the generalisability of these results is limited due to the small sample size (14 students). Furthermore, it is specific to the Dublin Institute of Technology. Conducting further qualitative research at Coventry University with mature students as well as traditional students may further reinforce (or challenge) the findings shared in this paper. Identifying engagement trends may help to determine whether there is a problem that needs addressing. It also must be noted that in the UK, a mature student is one that is over 21 years of age, whilst in this Irish study, mature students were those over 23 years of age.

Edwards and Carroll (2018) also investigated the effect of age on engagement with MSS. They reported on usage trends for varying demographic groups, such as gender, nationality, and English as a second language. Regression analysis on data from 657 first-year undergraduate mathematics students found that both gender and age were significant predictors when measuring engagement. Additionally, both female and older students were significantly more likely to seek support earlier (in relation to assessment dates). As the work by Edwards and Carroll was an Australian study, and Breen et al.'s (2015) work and that of O'Sullivan et al. (2014), discussed in the previous section, investigated Irish MSS, it is clear that demographic engagement is an international concern. However, there is a gap in the research. There do not seem to have been similar studies undertaken in the UK as of yet. Furthermore, many of these issues, such as non-engagement with MSS, became significantly more relevant due to the pandemic and the sudden transition to online support, and it will be worthwhile to see how usage of the support changed during this time, particularly to identify whether specific demographic groups used online support more.

Gender as a demographic factor connected to engagement was also reported by O'Sullivan et al. (2014). It was found that female students, who made up 42.4 % of respondents, availed of MLS significantly more than male students, regardless of both their course of study and their level of competency in mathematics. Ní Fhloinn et al. (2016) examined this phenomenon in more detail finding that being a female student increased the likelihood of engaging with mathematics support by 2.49 times, ($p<0.001$). Other factors had smaller effects, but the report overall highlighted the importance of investigating differential engagement with MSS.

In regard to disability as a factor, a paper published in 2020 discusses awareness of disabilities by staff involved in the lecturing of mathematics or in the provision of MSS (Cliffe et al., 2020). However, it only discusses the engagement of such students with the services briefly. Some of the challenges faced by these students will thus be highlighted to stress the importance of further research into the engagement of disabled students with MSS.

It is noted that mathematics learning resources in particular present a unique challenge to such students considering they are mostly in a PDF format, or occasionally, handwritten. Online support, whilst it may be of use to some students with physical handicaps, presents issues around the use of technology (Cliffe & Rowlett, 2012). It can be seen how this might hinder some disabled students from accessing MSS, such as if they have visual impairments. However, it must be remembered that whilst some resources might be beneficial to some, they may not be to students with a different disability. This is becoming increasingly recognised, as well as the increase in a more diverse student population, including students with disabilities. Cliffe et al. (2020) detail several case studies that have been shared on the unique challenges disabled students face in accessing support and work conducted on alleviating such challenges in HE in general. MA is also mentioned as one such accessibility barrier in Cliffe et al.'s (2020) research. The paper details the various supports available to staff and students as well as the awareness practitioners have of the supports. Future work also focuses on improvements that can be made to the provision of MSS to support students. This includes developing resources for practitioners, communicating with staff in Disability Services, and ensuring that any training of tutors includes how to work with students with accessibility barriers. The importance of conducting research in this field is apparent, and understanding whether students are using MSS for help will also be beneficial to future research. Mac an Bhaird et al. (2022) contribute somewhat to this by sharing that disabled and mature students think positively of the MSC at Maynooth University; however, quantitative data on student usage of MSS may also be of benefit, as comparisons across universities can be drawn more clearly and discussions can continue around effective practice.

A recently published paper by Schürmann and Schaper (2022) briefly describes the demographic background (gender, age and prior mathematics grade and score) of both users and non-users of MSS across six German universities. It is difficult to draw comparisons with the findings with no clear knowledge of the overall demographic population; however, further collaborative research may be worthwhile.

Ethnicity has not yet been explored in relation to student engagement with MSS. The importance of doing so, along with the relevant literature, is explored in Section 2.7.

It is also worth noting that there are also other one-to-one support services at universities, such as academic writing centres that also seek to investigate the engagement of students with their services, particularly in the post-pandemic setting (Parsons & Johnston, 2022). The findings from this thesis may therefore be beneficial to other such providers of support.

2.4.5 Methods to increase student engagement with MSS

As is discussed in the following section, many MSS services reported a reduction in engagement during the pandemic and providers have considered how to address this. However, trying to increase engagement with MSS has not solely been a question during or since the pandemic. For many years, interventions have both been proposed and implemented to increase the engagement with MSS, especially for at-risk students. The use of diagnostic tests in both sharing with students their weaknesses in mathematical areas, as well as in increasing engagement with MSS has been highlighted in many studies (e.g., Patel & Rossiter, 2009; Hyland & O'Shea, 2022; Hodds et al., 2022). These diagnostic tests are tailored to specific courses and cover the mathematical areas students should be competent in. However, this diagnostic test is only available to specific cohorts of students. Additionally, some students may find a test upon entry to university demoralising rather than motivating if they do not perform as well as expected. There has also been some discussion around the term "diagnostic test" being triggering, particularly for students with anxiety, and a movement away from this term at least may be beneficial. Some students may also be surprised to discover that their course has a mathematical component (Trott & Chinn, 2016), and for those suffering from MA, it may lead them to change courses, or even potentially withdraw from the university. The benefits of the diagnostic tests are clear and do appear to outweigh their potential drawbacks, but care should be taken that students feel supported throughout the delivery of the test and also upon receiving their results.

Other methods have also been employed, such as asking students to complete a "calculator survey". This survey is not a mathematics test; rather, it gathers information about students' attitudes to mathematics and statistics, as well as their knowledge of MSS. Upon completion of the survey, students can collect a free calculator from the MSS centre (Symonds et al., 2008). This can ease any anxiety students may feel about accessing the centre, as it is a low-expectation method of getting students to become familiar with it. This advertising strategy is another method for increasing engagement with MSS.

Symonds et al. (2008) also suggest employing more proactive strategies to increase engagement with MSS by changing the way mathematics is taught at university level in a manner that would motivate students to engage more such as using problem-based or inquiry-based learning. Symonds (2009) also discusses an initiative which identified less well-prepared students and taught them separately to the main group. The less well-prepared students were directed to the MSSC more often than the main group and also received an extra hour of lecture time. However, this initiative had mixed success with students initially engaging well with the support, and then, due to perhaps low marks in examinations, engagement dropped. Monitoring the performance of students in specific cohorts to ascertain their level of risk in failing and tailoring support and advertising to such individuals and cohorts has also been found to be of benefit (Lignos, 2019). This can be used in conjunction with other methods to ensure all students have the same access to support.

Patel and Rossiter (2011) reported on the results of moving the teaching of the mathematics module of an engineering course to the engineering department in order to provide students with context about the mathematics they were learning. A diagnostic instrument was also delivered to students as part of their induction, with students then being directed to the MSSC to collect a learning programme with helpful resources on learning mathematics. Feedback from students was positive about the change in teaching delivery and highlighted the importance of learning mathematics to students. The number of visits to the MSSC also increased as did student outcomes. Building student awareness of the services offered was also of importance. This was accomplished via various methods such as sharing posters, word-of-mouth, asking lecturers to share the information and other such techniques (Patel & Rossiter, 2009). It is also noted that building interpersonal relationships between MSS staff and teaching staff at universities is key to the MSSCs being promoted sufficiently. Strong relationships with faculty members need to be nurtured to ensure all students have equal access, and knowledge, of the support available (Hodds, 2020c). This became especially difficult during the Covid-19 pandemic, as highlighted in the following section, and so it would be interesting to see how this impacted student engagement with MSS.

2.5 Covid-19 pandemic

2.5.1 Impact of Covid-19 on general student engagement

Section 2.2 discussed the literature surrounding student engagement more generally, whilst the previous Section 2.3 discussed student engagement with MSS. This section considers student engagement during Covid-19 both generally and with support, where most MSS services reported a dramatic reduction in engagement (Hodds, 2020a). International studies (see Adedoyin & Soykan, 2020) have mentioned that lack of equipment, anxiety and poor internet connection were just some of the issues students faced during online learning generally. Simultaneous agendas, such as multiple classes, childcare responsibilities etc., (Muslimin & Harintama, 2020) were also considered to be a contributing factor to issues with online learning, as were students leaving online classes early since there was no real monitoring that occurred (Hazra & Priyo, 2022). It appears that lack of equipment and other aforementioned issues uniquely affect online learning. In particular, students having simultaneous agendas significantly impacts online engagement, even when, as is the case in Muslimin and Harintama's (2020) study, students had failed their regular class and needed this class to increase their score. Although this study had a relatively small sample size of ten students and may be seen as only localised issues to Indonesia, the studies mirroring these findings (Adedoyin & Soykan, 2020) use a mix of qualitative data collection methods such as questionnaires and interviews, and the number of studies using these methods highlights that these issues are potentially universal.

One of the recurring issues was that of countless students leaving their camera off during their online lessons (e.g., Hazra & Priyo, 2022; Castelli & Sarvary, 2021). This made it especially difficult for teachers to assess students' level of engagement with the lesson, which can usually be done through non-verbal cues such as body language and facial expressions. This was an issue for MSS practitioners, too (Gilbert et al., 2021; Hodds, 2020a). Banki (2021) combatted this by informing 17 students in their postgraduate human rights course that turning their cameras on was so that the teacher could monitor engagement, rather than attendance. This change in tone resulted in all students keeping their camera on, with over 95% attendance for those classes, a percentage of attendance that matched or even exceeded that of previous years.

Potentially more important than the issues mentioned so far was the lack of motivation students felt during the pandemic (Kohli et al., 2021). This lack of motivation was not only limited to a dislike of the online delivery of lessons; rather, the impact of the pandemic on student wellbeing also played an important part. One student succinctly summarised their personal reason for a reduced engagement as: “What’s the point of writing a paper when people I know are sick or dying?” (p.5) MSS relies on students to be autonomous and agentic in their learning, so this was a particular concern.

2.5.2 Changes in provision in MSS due to covid-19

Prior to the pandemic, the provision of MSS was primarily face-to-face support. As with all education services, the pandemic forced MSS to shift to online delivery, with some face-to-face support when government guidelines permitted. Fortunately, some institutions across the UK and Ireland had already begun to consider and implement online support (Mac an Bhaird et al., 2021; Ní Fhloinn & Fitzmaurice, 2021), although much of this was in the form of website help that linked to both internal and external resources. Lawson et al. (2002) is one of the first papers to discuss online support, although in this discussion, online was not the primary form of support as was required during the pandemic. Instead, it discusses the creation of a website to supplement, but not take over, the staff role in MSS, which is deemed to be central to the support. In 2011, there was an initiative to introduce a Shared Online Statistics Advisory Service (Owen et al., 2011), but despite the seeming effectiveness of delivering statistics support remotely, this initiative closed when its external funding ended. Since then, provision of online MSS has been very limited. Johns and Mills (2021) confirm that whilst face-to-face is the most common type of MSS provision, one-on-one online MSS has existed since the early 2000s. Grove et al. (2020) reported that, in their survey of 88 institutions offering MSS, a small number indicated that they had some real-time online MSS provision, but such provision was typically only available for one hour per week and providers of this support were quoted as saying “almost no take-up” and “Not often taken up” (p. 93).

This changed drastically with the onset of the pandemic. With face-to-face support impossible during the lockdowns, MSS practitioners began the move swiftly to wholly online support (Hodds, 2020a).

As described earlier, in pre-pandemic times, the issue of student non-engagement with MSS was one that was very important to the MSS community. During the pandemic, engagement with MSS fell dramatically in most institutions (Hodds, 2020a; Gilbert et al. 2021, Johns & Mills, 2021), with Mullen et al. (2021) reporting a 79% drop-in usage at one institution at the end of the 2020 second semester compared to that time period in 2019 despite the MSS service having been open for an additional three weeks. Another institution reported a 46% drop from April to December 2020 compared to the previous year (Mullen et al., 2021). Tutors explained that this may have partially been because “we still might not be reaching out to the students that would sort of just drop in… like they might have in the library because it was there (p.341)”, whilst a student suggested, “I’d guess a lot of people … either have trouble working out that they need help or have trouble telling other people that they need help (p. 341)”. The importance of social interactions in the context of MSS was highlighted by Mullen et al. (2022), with it being noted that valuable mathematics learning occurs amongst peers, which was more possible in a face-to-face setting. One student also spoke of a loss of connection with their peers and tutors, which has previously been noted as key in the setting of MSS. However, the feedback was not all negative. Some students noted online support was more accessible and that they were more likely to use online support.

What was interesting was that students were generally very open about disliking or being bad at mathematics, something tutors (anecdotally) also note and try to support students through. This was also noted to be more difficult in an online setting where body language and facial expressions were not able to be used to communicate (Mullen et al., 2021).

An in-depth analysis of usage data at Dublin City University (DCU) during the pandemic is given by Howard and Ní Fhloinn (2022). At DCU online support was delivered through the medium of pre-bookable 25-minute slots, with fewer time slots compared to the in-person hours that had been in operation before the pandemic. Staff kept their cameras on during the session. Some universities such as Coventry University (CU) offered both pre-bookable slots and drop-in online support, and CU staff mostly kept their cameras off. Interestingly, 62% of slots were booked by first-year students who had not previously used the in-person support, with 40% of these visits being made by students on courses with either a strong or exclusive mathematical component. At this institution, 736 visits were made online in 2020/21 compared to 4316 visits in 2018-19 supporting what Hodds (2020a) stated about the overall drop in engagement during the pandemic.

The presentation of mathematical text may also have caused some difficulties in both the learning and teaching of mathematics on an online platform, further exacerbating any issues faced in switching to online support with little warning. This was found to be the case, but with some interesting cases to note: as expected, the engagement of engineering students had decreased, but interestingly, the engagement of "traditionally mathematics-averse" students, such as bioscience and nursing students increased (Gilbert et al., 2021). Since these courses are typically female dominated, many practitioners in Gilbert et al. (2021) reported a higher proportion of female students using the support available. This research did not investigate the reason for this shift in engagement from engineering courses to health courses.

Despite this decrease in visits, the need for MSS only grows. Hodds (2023) explained the effect of the pandemic on the mathematical preparedness of students by measuring their performance on a diagnostic test, which found students are significantly less prepared compared to students who started university in 2020 or earlier. Their A level grades were also inflated; however, students arriving with lower grades at CU did perform better perhaps than their teacher-assessed grade suggested. These findings, paired with the difficulties in learning during the pandemic partly due to the absence of face-to-face teaching and that mathematics understanding has suffered (Shult et al., 2022), have only increased the need for MSS. Supporting these students with the mathematics on their courses is of paramount importance to help them in succeeding, and supporting their engagement with MSS is one way to do this.

The subsequent sections of this chapter will explore factors which may impact on engagement with MSS, namely MA and MR, as well as the ethnicity awarding gap.

2.6 Mathematics anxiety

It is likely that student engagement with MSS is related to student engagement with mathematics more generally. Many English-educated students are disengaged from mathematics from their high school years, perhaps due to the TIRED (Tedium, Isolation, Rote Learning, Elitism and Depersonalisation) approach commonly used when teaching mathematics (Nardi & Steward, 2003). Emotional trauma, caused in part perhaps by the current state of mathematics education (Johnston-Wilder & Lee, 2010b), particularly at GCSE level, contributes to higher levels of MA in many learners. These students approach their mathematics studies at universities with apprehension and associate negative emotions with mathematics. Some may even suffer from MA or 'math phobia', which is defined to be a "feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551) though many such definitions exist. Furthermore, MA is more than just a dislike towards mathematics (Marshall et al., 2016). It is characterised by avoidance behaviour, where students will go out of their way to avoid working with mathematics, a trait that may be evident in some who remain disengaged with MSS.

There are various scales used to measure MA, with one of the most notable being Betz's (1978) MA scale. It has been found to have satisfactory internal consistency and test-retest reliability (Dew et al., 1984, Pajares & Urdan, 1996). The scale can be used at any level of education due to its generalizable questions unlike other scales such as Hunt et al.'s (2011) UK scale MA, which asks for students' level of anxiety when answering certain types of mathematics questions, and the Abbreviated Maths Anxiety Scale (Hopko et al., 2003). Betz's (1978) has 10 items on a 5-point Likert scale, such as, "I feel at ease in maths classes" and "mathematics makes me feel uneasy and confused". The full list of items can be found in Appendix 1.

It is estimated that approximately 1 in 10 children suffer from some level of MA (Carey et al., 2019). In Johnston-Wilder et al. (2014), MA is said to contribute to the mathematics problem, though there is little awareness about the specific role it plays. This work also highlights how the findings of MA studies will be of importance to both the STEM and non-STEM sector, "since its presence could influence potential applicants in their choice of sector" (p.2). Furthermore, there is a correlation between student attainment in mathematics and instances of MA (Lee, 2009), and so helping students overcome their MA is of paramount importance.

This could be achieved via MSS, where one-to-one support is the preferred method of interaction (Croft et al., 2009). This has been shown to help students more than less-interactive lectures, as it perhaps more closely follows the ALIVE (Accessible, Linked, Inclusive, Valued and Engaging) approach (Johnston-Wilder et al., 2016, Johnston-Wilder & Lee, 2010b). In a coaching session designed to teach mathematics to students who were mathematically anxious this approach was used and it was said that "participants appeared comfortable" and were more engaged (Johnston-Wilder et al., 2016). Additionally, Marshall et al. (2018, p.5) claim that MSSCs "provide students with relaxing, non-threatening mathematics experiences in a supportive environment, and teach at a slower pace, allowing enough time for inquiry and individual development". Students have also commended the approachability of staff at MSS (Solomon et al., 2010) so students may perceive MSS as a 'safe place' (or, at least, a 'less threatening' place) to study mathematics. However, the idea that these responses were specific to an institution and may lack generalisability must be kept in consideration. Most MSSCs deliberately set out to create a non-judgemental, welcoming environment so the intention is that they should be 'safe places'; whether this is enough to overcome ingrained avoidance behaviour is another matter. Some authors (Symonds et al., 2008) have suggested that some of the "practical" reasons given by students for not engaging with MSS are masks for deeper-seated affective domain reasons. MA could be one such affective reason.

It is interesting to note that students with low levels of MA also tend to be more motivated individuals (Zakaria & Nordin, 2008), with a further claim that effectance motivation (the desire to act competently and effectively with the environment) is a predictor of mathematics achievement. Similarly, this can be seen in those students that are motivated to avail of the help offered by MSS, as they have found greater success with the mathematical component of their courses (Dowling & Nolan, 2006). However, it is worth noting that, along with MSS, many other factors, such as engagement with lectures, must be considered when analysing the success of the students that have sought help from MSS. Indeed, there is strong evidence of correlation between better performance and visiting the MSSC but more limited evidence of causation. However, MSS has been listed as a contributing factor to the continuation or successful completion of their studies (Ní Fhloinn et al., 2014) which cannot be taken lightly, due to the declining retention rates on STEM courses within universities (Smith & Naylor, 2001; National Audit Office, 2007).

Furthermore, one study (Abu Hilal & Al Abed, 2019), found that the relationship between MA and engagement is not necessarily simple. Low to medium anxiety scores correlated negatively with engagement ($r = -.23$, $p < .01$), whilst medium to high anxiety scores correlated positively with engagement ($r=.33$. $p<.001$). Further analysis revealing when students were grouped according to whether they had low levels of MA or high levels of MA, students who had high levels of engagement had low MA. Evidently, the relationship between MA and engagement is a complex one, with Dowker et al. (2016) suggesting that the causes of MA in high-achieving (particularly Asian countries) and low-achieving countries are different, with those in high-achieving countries potentially being anxious because of the importance that achievement in mathematics is given. Abu-Hilal and Al Abed's (2019) study was set in Oman, and as such, further research is needed on the relationship between MA and engagement in MSS in the context of the English education system.

The Yerkes-Dodson curve is one model used to explain the relationship between anxiety and performance despite much discussion around its validity because of its experimental design, which is succinctly summarised in (Nickerson, 2023).

It also appears that there is an inverted-u curvilinear relationship between MA and mathematics performance (shown in Figure 2.2) in students with high intrinsic maths motivation (Wang et al., 2015). This shows that some level of anxiety is conducive to good performance in motivated students, with the optimal level of arousal corresponding to the best performance. However, with too much anxiety, performance rapidly deteriorates. The type of anxiety does not seem to matter, and so some level of anxiety around mathematics, for example, may encourage help-seeking and a drive to do better. As soon as the anxiety increases beyond the optimal level, this drive rapidly drops, and this is where students may feel the embarrassment around their poor performance in mathematics and a need to avoid mathematics due to the feelings of inadequacy it brings. These feelings may be supported by comments made by caregivers, teachers, or those around them.

Figure 2.2

Yerkes-Dodson anxiety curve

Adapted from Wang et al. (2015)

Students with MA may exhibit certain self-handicapping behaviours, such as procrastination, in order to deal with the negative emotions they associate with mathematics and/or statistics (Onwuegbuzie, 2004). Recognising this in students as a coping mechanism, as opposed to misbehaviour, is key to helping them overcome their anxiety. It is essential that this avoidance behaviour is not seen as students avoiding mathematics, rather, they are seeking to avoid the negative emotions they associate with mathematics; it is not from laziness, lack of ambition, nor rebellion. It is therefore clear that students suffering from this must be treated sensitively.

These self-handicapping and avoidance behaviours may be prevalent in those that do not engage with MSS services, some of which have even been cited by students. In the study of O'Sullivan et al, (2014, pp.45-46), "I was afraid or embarrassed to go" was an option selected by around 12% of participants, as reasons as to why they do not engage, with "Wanted to go but haven't been motivated" a reason a student gave under "Other". The possible link between MA and non-engagement with MSS makes this a relevant avenue to explore. Razak (2020) raises the question of how MA can be reduced through using e-learning, which may be a worthwhile pursuit since many MSS centres now do offer some form of online support. The effectiveness of this is yet to be determined and will be shared in a subsequent article of Razak's. Other interventions have aimed at decreasing MA focus on different elements, such as improving their mathematics skills, and mindset interventions (see Ramirez et al., 2018), although some of these are not appropriate for an intervention aimed at university students. It is also necessary to consider the cost and time effectiveness of such interventions especially in the current climate of higher education.

Fear of failure, lack of effort and avoidance of mathematics-related activities are all classic indicators of MA (Marshall et al., 2017). As such, interventions which focus primarily on helping students overcome their MA, primarily via an increase of their MR (as shown in the next section) in order to combat their MA are becoming increasingly common (e.g., Para & Johnston-Wilder, 2023; Chisholm, 2017; Johnston-Wilder et al., 2014).

It is also important to somewhat separate MA from statistics anxiety (SA). SA can affect a student's statistical ability in modules where an understanding of how to use statistical software is tantamount to success with their course (Rendulic & Terrell, 2000) and also has a negative impact on the academic performance of students (Macher et al., 2013). It is a multidimensional construct that is related to three factors: previous mathematics experience and skills, mathematics self-esteem, self-efficacy towards statistics, and personal factors such as gender and age (Onwuegbuzie & Wilson, 2003).

Due to its complex nature, it can be difficult to gauge the relationship of SA with other variables such as MA. As such, the relationship between MA and SA is controversial; many studies (Murdock, 1982; Yager & Wilson, 1986) view them as similar constructs, whilst others view them as two separate constructs, with Onwuegbuzie et al. (1997) reporting that those who reported high MA did not necessarily report high SA. Additionally, despite statistics having roots in mathematical ideas, Baloglu (2004) found that statistics is more akin to verbal reasoning than mathematical reasoning. This all indicates that MA did not have a clear effect on statistics performance, despite it having a clear effect on overall outcomes in education.

However, in Primi and Cheisi (2018), when the relationship between MA and SA was explored in Psychology students, MA is the best predictor of SA and similarly, an antecedent of SA, agreeing with the findings of Baloglu & Kocak (2006). Other researchers have also found an inverse relationship between MA and statistics performance (for example, Bendig & Hughes, 1954; Hunsley, 1987; see Onwuegbuzie & Wilson, 2003). This further highlights the importance of treating MA and SA as two individual, but related, constructs, and supporting students with MA, even if they are studying statistics. For this reason, as well as difficulties in recruiting a reasonable sample of students, this research primarily focuses on MA.

2.7 Mathematical resilience

Mathematical resilience (MR) has been defined to be “a positive approach to mathematics that allows people to overcome any affective barriers presented when learning mathematics” (Johnston-Wilder & Lee, 2010a, p.1). It is characterised by a growth mind-set, in that students with a growth mind-set understand that mathematical capability is not fixed but can grow with appropriate effort and learning environment (Dweck, 2000), an understanding that struggling is ‘par for the course’ and acknowledging the value of mathematics (Johnston-Wilder & Lee, 2010b). Thus, MR is considered a three-dimensional construct with dimensions of mindset, struggle and value. Typically, it is measured using a questionnaire instrument (Kooken et al., 2013) where the scores on the three sub-scales are added to derive an overall MR score. There has also been discussion around the addition of a fourth subscale, community, which has not yet been validated (Lee & Johnston-Wilder, 2017).

Studies such as Thornton et al. (2012) were completed before the development of an MR scale, yet their findings are still relevant since they are consistent with those found in studies after the scale was developed (Johnston-Wilder et al., 2014), particularly the importance of students/apprentices seeing value in the mathematics they learn. Furthermore, the well-established MA scale by Betz (1978) was incorporated in a study by Johnston-Wilder et al. (2014) that measured both the MR and MA of apprentices. Johnston-Wilder’s study investigated the prevalence of MA and MR amongst apprentices, differentiating between the type of apprenticeship, gender and prior qualification. It is worth noting that any intervention aimed at reducing MA, perhaps one that will also aim to increase their MR, will have to be carried out when students are not close to their examination period to avoid test anxiety influencing the results, and thus affecting the validity of the study.

It has been suggested that helping students to have control of any negative emotional responses to mathematics (where these occur), may be more effective than simply mathematically-training students (Lyons & Beilock, 2012). Increasing MR may be a way of controlling a student’s anxious response to mathematics, and may show the students who, having a fixed mindset, believe they have no talent in mathematics and therefore avoid the subject, that mathematics knowledge actually is accessible to them.

Johnston-Wilder and Marshall (2017) make mention of the sessions and workshops the authors have held to help students with high MA and have highlighted the need to work one-to-one with learners who would benefit from immediate help. Furthermore, there is mention of a one-to-one MR intervention that has been developed for both students and mathematically anxious colleagues. These interventions can be tailored for usage in MSS centres, where students with some degree of MA can attend, particularly since engagement with MSS depends on students being agentic with their learning. As mentioned above, these workshops can be used to develop a student's agency, which could increase their engagement with MSS. However, the durability of these interventions needs to be questioned. Though such interventions have proven to be useful, they are also time-consuming, and with the time constraints on staff to satisfactorily support students, these interventions may need to be adapted to be less staff time-intensive.

It is also important to note that MA and MR are not opposites; high MR and high MA are not mutually exclusive. Increasing MR in a student will not 'cure' a student of their MA; rather, it equips students with a mechanism to combat the effects of their MA. It also needs to be considered that students who may already be prone to "generalised" anxiety may not benefit from such an intervention alone, and professional psychological intervention may be necessary. Due to the sensitive nature of the topic, training may be required on any tutor's part to ensure no harm comes to the student.

There are potentially two kinds of interventions: Interventions that aim to reduce MA i.e., that try to make students less mathematically anxious so that they do not experience extreme negative emotional reactions when faced with having to do mathematics; and interventions that aim to mitigate the impact of high MA i.e., they do not stop students experiencing the flight reaction to maths but they train students to combat this flight reaction and be able to learn maths anyway.

As evident from the previous sections, student engagement with MSS is of concern, particularly since the pandemic has had a debilitating effect on engagement overall. Identifying the effect of MA and MR levels on engagement with MSS may also be beneficial in providing a direction for how to increase engagement if it is found to be a factor. Another potential factor to be explored is differential engagement with MSS, in particular, the relationship between ethnicity and engagement with MSS since this has not yet been explored in research.

2.8 Ethnicity awarding gap

It is important to firstly clarify the terminology that will be used in this section to discuss the ethnicity awarding gap. There have been many discussions at various universities about the inconsistencies in terminology, and the issue lies in whether those students from the ethnicities mentioned here are content with the descriptions applied to them. It is noted that each student from each background has a unique experience with university and their experiences will affect them in vastly different ways. Despite being referred to under the same umbrella term, the 'ethnicity members' of this group are by no means seen as sharing uniform traits. The preferred terminology that will be used herein is "ethnically diverse", as opposed to BAME (Black, Asian, Minoritised Ethnic), which is reductive and divisive, or ethnic minorities, as these terms appear to paint racialised students as lesser or disadvantaged. It also "constructs the identity of racialised people in relation to the dominant white population (p.1)" (Maharaj, 2021) where whiteness is the reference and the norm against which people are judged. The term ethnically diverse may be more appropriate and acceptable as it is a broader and more inclusive term than BAME, which categorises people into just four groups. Due to the nature of the awarding gap, ethnically diverse students are often assessed against white students. This is because the focus is on trying to understand the differences in attainment and giving students equal opportunities. Whilst even the term ethnically diverse is not fully inclusive and some may not want to be classed as such, it is difficult to find a single term that encompasses all the nuances of ethnicity and represents the global majority of these ethnicities. Nevertheless, this research makes every effort to take this into account.

The ethnicity awarding gap refers to the difference in the proportion of first or 2:1 degrees honour classifications being awarding to White British students and UK-domiciled ethnically diverse students. The awarding gap between Black and White students is consistently worse than the gap between the other ethnically diverse communities (Universities UK & NUS, 2019). In much of the literature, this awarding gap is referred to as an attainment gap, with the movement to a change in title having only been discussed recently. An attainment gap suggests a student deficit model, where the explanation for the gap is seen to be found in factors relating to the students, whilst an awarding gap suggests "structural factors, including institutional racism and ethnic bias, can best explain the gap" (Nyhagen, 2022, p.1). In other words, the deficit lies with the institution and its processes not with the students.

In recent years, universities have begun to both acknowledge that such a gap exists and have initiated interventions to tackle it (Universities UK & NUS, 2019), highlighting a shift in attitudes around this; however, Singh (2011) suggests that some HEIs are still in denial regarding the ethnically diverse awarding gap, or reduce it to a deficit model. Acknowledging that a gap exists and that measures must be taken to tackle this is key to working towards expelling institutional racism.

The attainment of different groups of students have come under further scrutiny in recent years, with ethnicity in particular being a predictor of differential achievement. Despite controlling for age, gender, discipline, and prior attainment, students from most ethnic minority backgrounds are still obtaining poorer degree outcomes than white students, though there is a significant decrease in the gap relative to when these factors are not controlled (Smith, 2019). Identifying students that do not engage with MSS may provide evidence of a disparity between the ethnicities of those that utilise MSS, mirroring the awarding gap. If evidence of difference in engagement is found, then it will prompt two questions: “Why does the engagement gap exist?” and “What steps can be taken to reduce it?” Should it be found that no gap exists or that ethnically diverse students engage more, it provides further evidence that the awarding gap is not a student issue.

Panesar (2017) highlights that there is a belief by some that ethnically diverse students engage with academic support at a lesser rate than white students. Using University data, Panesar (2017) found that in actuality, between the academic years of 2012-2015, ethnically diverse home students attended academic support at a higher rate than their white home counterparts when analysing institutional data from a school within the University that had a particularly wide awarding gap. It was also found that for this school, in 2014-15, the gap was reduced to becoming the smallest gap from any of the UAL colleges. Whether the higher outcomes of ethnically diverse students can be attributed to the level of engagement with academic support, is yet to be determined. Here, it is important to remember that each institution is different, and data from each institution may reveal different results. This only highlights Panesar’s point further, in that using institutional data to research ethnic inequalities rather than making assumptions about engagement is of paramount importance. Should it be found that such inequalities do exist, interventions may also have to be tailored to each institution.

Most research into the attainment gap is of a quantitative nature (Cotton et al., 2016), which will undoubtedly help gauge lack of engagement with MSS but does not delve into the affective domain of the students to properly ascertain the size of the problem. Adopting a mixed methods approach to tackle this issue is the most logical solution, as both sets (qualitative/quantitative) of data will complement each other; quantitative research will highlight the scale of the problem, whereas qualitative research may identify the reasons as to why this problem arose, and whether increasing ethnically diverse engagement with MSS through the development of an intervention is viable.

2.9 Conclusion

This chapter reviewed literature pertaining to student engagement with MSS, beginning with the mathematics problem, which led to the establishment of mathematics support across the country. Although the success of MSS has been repeatedly established, it has been observed that many students who could potentially benefit considerably by engaging with MSS fail to do so. There is little research around identifying the characteristics of those students who could benefit but do not engage.

The following sections further investigated literature around the construct of student engagement as well as how student engagement may look in relation to mathematics support. Examples of previous research undertaken to increase student engagement with MSS was also shared, as well as the reasons students provided for their non-engagement.

A connection was established between MA and student engagement with mathematics; further research showed interventions that had been created to help students combat their MA by increasing their MR. Again, to the author's knowledge there was no literature at the time of study that showed the effects of increasing MR on engagement with MSS. On the other hand, the relationship between engagement with mathematics in general and MA remains complex.

There is currently much focus around the attainment of ethnically diverse students, but very little, if anything, is known about their level of engagement with MSS. Since there is much evidence establishing the positive relationship student engagement has with attainment, evaluating the engagement of ethnically diverse students with MSS is a relevant avenue to explore.

Although there has been considerable research dedicated to understanding the effect of the pandemic on higher education, these papers merely provide a starting point on which further research may grow. The unprecedented circumstances through which countless changes occurred has left higher education in a state of flux, and therefore, now that some form of normality is returning, it is imperative that these changes are evaluated for both their successes and shortcomings. The impact of COVID-19 on all factors discussed herein will be taken into consideration where possible as it is clear to see its impact on not only the delivery of MSS, but also the psyche of the students and practitioners alike, and its effect on engagement.

This thesis therefore aims to provide some insight into student characteristics of both those that choose to engage and those that do not engage with the support available, as well as their reasons for their level of engagement. Further to this, more research will be conducted on the effect of MA and MR on student engagement with MSS. The findings will be combined to produce recommendations for future practice to increase engagement with MSS.

3 Methodology

3.1 Introduction

In the previous chapter, it was demonstrated that although some research has been conducted on understanding student engagement with MSS, there are several gaps that must be addressed. One such gap is a complete demographic profile of users of MSS so that, should a difference in engagement between different demographic groups be found, MSS services can address this through further research and/or specific targeted interventions. Additionally, creating this user profile will contribute to work in the field of the awarding gap, where there is a belief that the difference in attainment between white and ethnically diverse students may be tackled by increasing the engagement of ethnically diverse students with academic support such as MSS. This research aims to use institutional data to tackle this assumption, as advised in Panesar (2017). Another area of research that may contribute to the field is that of MA and MR. Whilst MA has been found to have a dampening effect on student engagement with mathematics, it is yet to be discovered whether this extends to engagement with MSS, too. Likewise, building students' MR has been shown to have a positive impact on their engagement with mathematics, but no such relationship has yet been identified with their engagement with MSS. Additionally, it was suggested in Symonds (2009) that the structural reasons given by students for their non-engagement may be a mask for affective reasons. Another aim of this research is to investigate this hypothesis and determine student reasons for their level of engagement.

The overall aim of this research was to investigate student engagement with MSS and what actions may be taken to increase engagement with the service. Through this, recommendations for future practice may be generated and disseminated amongst providers of MSS and mathematics and statistics in general.

This chapter firstly provides the overall research questions this thesis aims to answer, along with the rationale for each question. An overview of the relevant philosophical foundations of research pertinent to this study are provided, followed by in-depth description of how these methodologies were used to create the theoretical framework of this study. This includes the data collection methods used and their purpose. Finally, some attention is given to the ethical considerations made during this study.

Due to the complexity of "student engagement", the answers were sought through both qualitative and quantitative data. Thus, the key aims of this research are to identify characteristics of users and non-users of MSS, to understand what factors may potentially impact on engagement (such as MA and MR and how these may be targeted to increase engagement), and finally, to determine student reasons for engagement.

3.1.1 Research questions

This research study aims to provide a considerable contribution to the answering of the following questions:

RQ1) How do student characteristics affect student engagement with MSS?

RQ2) What effect, if any, do MA and MR have on student engagement with MSS?

RQ3) What is the effect, if any, of developing students' levels of MR on their engagement with MSS?

RQ4) How do students explain their level of engagement with MSS?

An overview of the research questions, the data used to answer these, along with the methodology and analysis used for each is found in the diagram below.

Figure 3.1

Diagram detailing relationships between data type, research questions and analysis

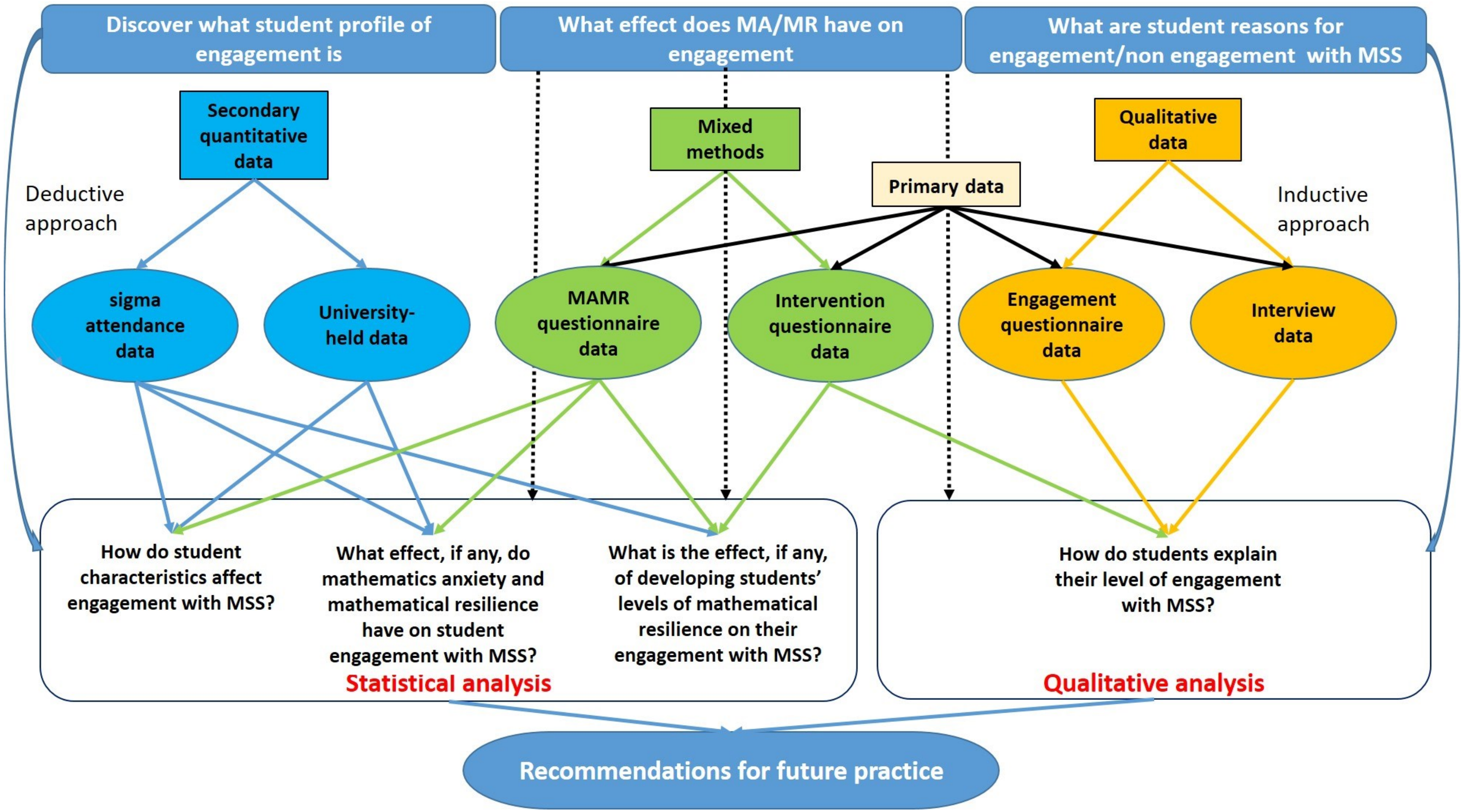


Figure 3.1 outlines the research methodology followed in order to answer the research questions. The arrows depict how the research is related. This figure depicts the process of the research. The findings of any subsequent analysis run will inform the development of the framework of engagement. The recommendations will be relevant across universities that provide MSS, furthermore some suggestions may also be adapted for increasing student engagement with mathematics and statistics throughout their education.

The information from the diagram will now be built upon.

3.2 Theoretical framework for this study

3.2.1 Qualitative and Quantitative research

A paradigm is "the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed" (Kuhn, 1970). It determines how the research will progress, whilst the different schools of thought (positivism, constructivism, etc.) influence the research method and strategy chosen.

Once the paradigm that will guide the research has been decided upon, any data collection methods, and the methods used for analysing the data, are determined by the researcher. The data that is collected and the way it is analysed will be influenced by the chosen research paradigm.

Figure 3.2

Research strategies and methods commonly used in social science research

Adapted from Johannesson and Perjons (2014)

Qualitative research stems from constructivism and deals with the development of subjective meanings and understandings of an individual's personal experiences concerning specific topics based on their social and historical background. The premise is that understandings about the world are constructed and interpreted by people (Kamal, 2019). Quantitative research, on the other hand, follows a positivist approach, which states that truth exists independently of people; instead, it is based upon the observation or manipulation of natural events.

A second difference in how research can be conducted is through either the inductive or deductive approach. Deductive reasoning, which is associated with quantitative research, is logical and syllogistic. Syllogism can be explained to be a form of a formal argument that consists of two (assumed-to-be) factual premises that lead to a conclusion, which may or may not be factual itself. As long as the assumptions made are true, the conclusion will be true. It is also imperative that the order of the premises is correct. An example used to demonstrate syllogistic reasoning is: All numbers ending in 0 or 5 are divisible by 5, and the number 35 ends with a 5, so it must be divisible by 5. All premises are correct; therefore the final statement is also correct.

However, inductive reasoning – associated with qualitative research and the importance of observation – is where the premises provide some, but not complete, evidence towards the conclusion, meaning the conclusion cannot be guaranteed to be entirely factual. An example of this is: Most of our snowstorms come from the north, and it's starting to snow, so this snowstorm must be coming from the north. The premises in this example may separately be true, but the conclusion is invalid because it has overgeneralised.

The order in which research occurs in both instances can be seen below.

Figure 3.3

Flow diagram comparing the inductive and deductive approach to research

Adapted from Newman (2000)

When using the deductive approach, it is clear to see that the hypothesis is formed through thorough theoretical research on the topic. Data is then collected and analysed to either substantiate the claims made by the hypothesis, or to indicate that the hypothesis may need to be revised. Alternatively, in the inductive method, it is in fact the data collection and analysis that informs the development of theory.

Qualitative research often involves collecting data primarily through observation of participants (either overt or covert) and/or interviews and hence can be subjective. The data collected is usually non-numerical and aims to understand experiences and opinions. Qualitative research usually follows an inductive approach, whilst quantitative research, since it is developed through research, follows a deductive approach.

Though qualitative research has many benefits over quantitative research, such as depth of detail, it is not without its flaws. The depth of detail it provides comes at a cost of its results usually being more difficult to measure and replicate, reducing its reliability. It also requires a considerable amount of additional time to both collect and analyse any data, some of which may actually be lost due to the researcher not recognising necessary data findings as important, thus reducing the accuracy of the results (Gaille, 2018). There is also a greater likelihood of researcher bias since the researcher usually has to interpret the collected data.

Quantitative research mitigates these disadvantages as it is less time-consuming to collect the data and the analysis can be more straightforward. The results may also be more reliable as there is less chance of researcher bias, and therefore less chance of error (Devault, 2020). This is because the data is numerical and does not require interpretation, unlike in qualitative research. However, it is worth noting that sample size of the data being analysed can have a large effect on the significance of the findings. If the sample is not representative enough, there may be a worry of drawing incorrect or unrepresentative conclusions.

The differences between the two methodologies are summarised in Table 3.1, whilst their strengths and weaknesses are highlighted in Table 3.2.

Table 3.1

Differences between qualitative research and quantitative research

Qualitative Research	Quantitative Research
Constructivist	Positivist
Inductive approach – data driven	Deductive – theory driven
Research questions are exploratory	Research questions are based on hypotheses
Provides in-depth understanding of subject	Provides evidence of the existence/non-existence of relationships between variables
Provides rich information on topic	Provides generalisable and reliable information
Typically interviews and/or focus groups	Typically questionnaires

Table 3.2

Strengths and weaknesses of qualitative research and quantitative research

Qualitative Research	Quantitative Research
Limited objectivity, thus lowering its verifiability	More objective
Provides rich details on values, beliefs and assumptions	Limited human perspective on results, reducing the richness of the data findings
Difficult to repeat study due to various factors that may interfere with results	Generalisable as the study can be more easily replicated
Time-consuming if using interviews/focus groups	Short time-frame for data gathering

There has been much debate about the combining of both qualitative and quantitative methods, particularly due to the fact that they are both based on very different epistemologies. The concept of mixed methods of research was debated for almost three decades (Tashakkori & Teddlie, 2003), and has resulted in much literature surrounding the combination of the two different types of research. In fact, studies combining both quantitative and qualitative research were seen before the emergence of "mixed methods research" as an accepted methodology (Maxwell, 2016).

However, over the last few years, the focus has been redirected to choosing a paradigm that is best suited to the nature of the research, instead of advocating for a particular research paradigm. Schwandt (2000, p. 210) succinctly summarised it as, "it is highly questionable whether such a distinction [between qualitative inquiry and quantitative inquiry] is any longer meaningful for helping us understand the purpose and means of human inquiry" and "All research is interpretive, and we face a multiplicity of methods that are suitable for different kinds of understandings. So the traditional means of coming to grips with one's identity as a researcher by aligning oneself with a particular set of methods (or being defined in one's department as a student of "qualitative" or "quantitative" methods) is no longer very useful. If we are to go forward, we need to get rid of that distinction."

As a consequence of focusing on methods that are best suited to the topic being researched, there has been a growth in the use of so-called mixed methods research design, and it is now thriving as a popular choice in research studies. The logic of inquiry for mixed methods clearly does not follow either an inductive (data-driven) or deductive method (theory-driven) unless it is split into its qualitative and quantitative components. However, as mixed methods research is usually a means to understand or explain a topic rather than just testing hypotheses or generating theory, it follows what can be seen as an inductive-deductive approach i.e., an abductive (explanation driven) approach (Hiles, 2012) may be better suited in some cases than having the type of data dictate the logic. Theory is not used to make any predictions, and neither does the theory emerge from the data; both are presumed, and as such, abductive inference is about discovering what the best explanation for the data is. However, for the purpose of this research, since the distinction between the qualitative and quantitative strands of research were so definitive, in the research design, it was decided to use inductive or deductive logic to guide the study as appropriate.

A mixed-methods approach allows the strengths of both paradigms to support the research. It also lessens the importance of some of the drawbacks of each, such as the subjectivity of qualitative research. This is because if the quantitative analysis conducted alongside it presents the same results, the quantitative research reinforces the findings from the qualitative research. The research questions in this study are answered through a combination of both qualitative and quantitative techniques, and as such, the next subsection focuses on mixed-methods research designs and how this is implemented.

3.2.2 Mixed-method research designs

Pragmatism is now seen as the third research paradigm, situated between constructivism and positivism. There are many mixed methods research designs, though Creswell and Creswell (2017) has narrowed these down to four key design categories, namely, the Embedded design, the Exploratory design, the Explanatory design, and the Triangulation design. These four key designs will all be briefly explained in the subsequent sections.

Embedded design

This design is used "when one type of data is most critical to the researcher" (Terrell & Edmonds, 2017), such as if the quantitative data is only there to support the main qualitative approach taken, and as such, the quantitative component is "embedded" into the qualitative methodology. Both are used to answer the different research questions within the study (Hanson, et al., 2005). Though this design is useful for those who do not have sufficient resources or time to commit to more extensive data collection, it can prove difficult to combine the results of the two methods when they have been used to answer two different research questions. Also, very little has been reported about embedding quantitative data into qualitative designs, which may end up taking up the considerable time that may have been saved from choosing this research design (Creswell & Creswell, 2018).

Exploratory Design

This design works in a way where the results of the first method chosen can inform the development of the second method. This design begins with qualitative research that is then used to inform the quantitative aspect of the research, usually because variables are perhaps unknown or a new instrument has to be developed and tested (Creswell, 2003). This design is also referred to as the Exploratory Sequential Design (Creswell, et al., 2003) because of its format. It is a method that is more flexible to change and can be used to lay the groundwork for future studies. However, the findings of these studies tend to have smaller sample sizes, and thus, the findings cannot be generalised to the wider population (Dudovskiy, n.d.).

Explanatory Design

This is similar to the Exploratory Design in that it is also a sequential design. It contrasts with the Exploratory Design as it begins with quantitative data collection, of which the results inform the collection of qualitative data. An example of when this design would be used is when quantitative data is analysed to discover relationships between variables, and qualitative data is subsequently collected in the hope of explaining the patterns and trends identified using the quantitative data. Being a sequential design, it is easy to implement since the data does not need to be collected and analysed simultaneously. However, like the other research designs, this can mean it is quite time (and effort) intensive.

Triangulation Design

This design aims to "obtain different but complementary data on the same topic" (Morse, 1991). It combines the varying strengths and weaknesses of quantitative methods with qualitative methods – which as mentioned is one of the main reasons a mixed methods research design is chosen for research. This design is used when a researcher wishes to consolidate findings of quantitative analysis with the more in-depth findings from qualitative research. In the convergence model, neither set of data has more weighting than the other, the data is collected simultaneously, and then the results from both are compared and merged (Creswell & Plano-Clark, 2011). However, one of the failings of using this design is discovering how to determine the outcome of the research if the findings from all branches of the research do not agree. The contradiction in findings potentially indicates that the situation is more complex than had previously been envisaged, and the only way to perhaps uncover the reason for this is the collection of further data, which can be time-consuming.

The four designs are summarised below.

Table 3.3

Overall definitions of 4 key mixed method research designs

Design	Definition	References
Embedded	one data set provides a supportive, secondary role in a study based primarily on the other data type	(Creswell et al., 2003)
Exploratory	qualitative data is first collected and analyzed, and themes are used to drive the development of a quantitative instrument to further explore the research problem	(Teddlie & Tashakkori, 2008)
Explanatory	collecting and analyzing quantitative and then qualitative data in two consecutive phases within one study	(Ivankova, 2006)
Triangulation	mixing of data or methods so that diverse viewpoints or standpoints cast light upon a topic	(Olsen, 2004)

In view of the research questions this study sets out to answer, it was decided to adopt a mixed-methods approach in order to maximise the benefits of each paradigm. A mix of both primary and secondary data was used to answer the proposed research questions. Quantitative research methods are more suited to answering whether there are differences in levels of engagement with mathematics and statistics support based on demographic characteristics, whilst qualitative methods are more useful for answering questions about why such differences exist. Quantitative methods gave an overview of what student behaviour appeared to be, but without student feedback, it would be impossible to know whether any inferences around engagement based on the data was correct. For example, the quantitative data might show a correlation between two characteristics e.g. non-engagement and high levels of mathematics anxiety whilst qualitative data may provide evidence for causation. In this research, the triangulation design was used due to the above reason: some details about students' non-engagement may be revealed through the quantitative analysis, but a deeper understanding of their reasoning can only be acquired through obtaining qualitative data. The convergence model was used so that the findings of the quantitative results could be corroborated with the qualitative findings. This design is followed when both sets of data are collected and analysed separately, and the different results are then converged (Creswell & Creswell, 2018).

Initially, this research was intended to follow the explanatory design, but practicalities forced the research to follow a triangulation design instead. The analysis of the quantitative data was intended to inform the development of the questionnaires, and in particular, decide the target groups for the intervention. However, due to a delay in the acquisition of a complete dataset, to ensure the project proceeded in a timely manner, the creation of the questionnaires and intervention occurred alongside the analysis of the preliminary datasets, informed instead by the literature reviewed. The pandemic also interfered significantly, particularly with the data collection since students could only be recruited online.

Quantitative methods were used to determine which demographic of students did not engage with MSS services. MSS attendance data for the academic years of 2018/19 and 2020/21 was analysed alongside student information such as age, ethnicity, gender and nationality. The academic year of 2018/19 was a year in which MSS provision was entirely face-to-face as were lectures. However, the 2020/21 academic year was drastically different and a year of complete uncertainty in light of the pandemic. Learning was predominantly online, as was MSS, excepting a few short periods of time where government guidelines allowed otherwise. Though this analysis shows which students are not engaging, it does not shed any light on why they do not engage. This is where qualitative methods were used to discover the underlying reasons for student non-engagement with MSS. Both the qualitative and quantitative data were investigated at the same time to avoid the issue of researcher bias (which may have occurred if the researcher already had knowledge on which groups of students did not engage).

Questionnaires and interviews were used to examine student non-engagement further.

The following subsections will give an overview of data collection methods, as well as further detail of both the sources of data used in this study, the data collection methods used, as well as the methodologies followed throughout.

3.3 Data collection methods

There are a wide range of data collection methods, some of which are best suited for qualitative research and some for quantitative. Some of the most commonly used methods of data collection are described below.

3.3.1 Questionnaires

Questionnaires are able to collect detail about people's opinions, knowledge and attitudes quickly. They can also be adapted for use more simply than other methods, making them more cost-effective too (Phellas, et al., 2011). Questionnaires have many advantages such as being relatively quick to administer and receive data from, especially in comparison to more time-consuming data-collection methods such as interviews. They can also reduce bias that may be more prevalent in interviews conducted by the researcher. Modern software such as Jisc Online surveys enables the rapid collection of data in electronic format that is easily imported into data analysis tools such as SPSS or Excel. The use of Online Surveys also makes it easier to reach a wide range of participants, even internationally, meaning that a large number of responses can be gathered with relatively little effort on the part of the researcher.

However, if a participant is uncertain about a set question, they are unable to ask for clarification. Likewise, if they respond ambiguously to an open-ended question, the researcher is also unable to ask for clarity. Furthermore, the participants that choose to answer the questionnaire may be more motivated than those who choose not to, possibly making the results biased. This could be an issue, particularly in the case of certain questionnaires, such as when the topic explored relates to something which may provoke an emotional response.

3.3.1.1 Design of questionnaires

When designing a questionnaire, it is imperative that the questions are worded carefully enough that they are able to be answered reliably. To ensure this, a number of factors must be considered before delivering the questionnaire.

Type of questions

Firstly, the type of questions must be chosen. There is a choice of either open or close-ended questions, where the former gives the respondent the opportunity to answer in their own words. The latter gives the respondent a list of options to respond with. Open-ended questions have the benefit of getting rich, meaningful data, but responses given can sometimes be difficult to code, which is similar to the drawbacks of qualitative research. Participants also may be less interested in giving an open-ended response since they take more time and effort to formulate a response (DeFranzo, 2018). However, close-ended questions are much easier to administer and analyse, despite sometimes making participants feel forced to answer a certain way if the responses given do not adequately represent their opinion.

Wording

It is also essential that the wording of the questions is kept simple, and does not confuse the reader by asking for too much information in one go. Complex language must be avoided, or explained prior to the delivery of the question. To avoid bias, question wording must not lead the participant into answering in a particular direction. Each question should also only ask one thing to avoid confusion.

Order

Setting up a "context effect" is another way of creating bias in a questionnaire. This is when the order of the questions leads the respondent into an answer. In some surveys, it may involve giving the respondent previous information (i.e. context) about an issue, and then asking them their opinions on the issue.

Response Categories

Response categories must be balanced so there is not an uneven weight on either side of the argument. It may be preferred that there is a middle option for respondents, such as "Neither Agree nor Disagree", or "Undecided". Alternatively, there need not be a middle option, as long as there is an equal number of both "positive" and "negative" responses. This again lessens the chance of participants responding in a way that does not truly reflect their opinion.

Scales

A scale is a particular type of questionnaire where the participant answers a series of "questions" (which might be about their level of agreement with a statement, known as a Likert scale). A score is given for each answer and the scores are totalled to determine a "measure" of the characteristics being studied. A validated scale is one that has had all its questions tested through correlation analysis to determine whether it measures what it intends to measure. These validated scales are used as references in studies when appropriate, especially since they can become the standard tool for measuring particular characteristics. When a scale is not available, or those that are, are not suitable nor appropriate for the study, a new scale may be developed (Tsang et al., 2017).

There is a debate about the use of parametric approaches to analyse data from Likert scales. There is a clear consensus that individual items on a scale are treated as ordinal data, but it is not so clear for the scales that combine multiple items, such as Betz's MA scale. However, Carifio and Perla (2008) argue that the weight of evidence is vastly in support of using parametric approaches to analyse such data, highlighting that “a variety of studies have shown that the Likert response format produces empirically interval data at the scale level” (pg. 1150), concluding that “it is perfectly appropriate, therefore, to sum Likert items and analyse the summations parametrically” (pg. 1151). In addition to this, the use of parametric approaches to analyse Likert data is very common in the published education research literature (Chen & Liu, 2020).

3.3.1.2 Usage of questionnaires in this study

In order to answer the research questions it was necessary to measure students’ levels of mathematics anxiety and mathematical resilience. Furthermore, it was desirable to obtain information not only about levels of engagement with MSS (provided by the attendance data) but also insight into students’ perceptions of the reasons for their levels of engagement. The former was achieved through the delivery of a mathematics anxiety and resilience questionnaire whilst the latter was achieved through the delivery of a student engagement questionnaire. Established scales exist for measuring MA and MR whilst the author created their own questionnaire to gather more detailed engagement data. The combined MA and MR, and the engagement questionnaire, can be found in Appendix 1 and 2.

The findings from the mathematics anxiety and resilience questionnaire were matched to student attendance data to identify their level of engagement with **sigma**. The resilience questionnaire provided base anxiety and resilience levels for the students who took part in the intervention. Whilst the aim of the engagement questionnaire was to provide some insight into the reasons of students’ level of engagement with **sigma**, further detail could be obtained through means of interviews. However, it was thought that students would be less likely to participate in interviews and so questionnaires would be useful to collect students’ opinions quickly, even if the answers were brief.

Scales used in this study

The characteristics of interest in this study are mathematics anxiety and mathematics resilience. Published scales were incorporated into the Mathematics Anxiety and Resilience questionnaire (refer to Appendix 1), namely the Mathematics Anxiety Scale (Betz, 1978), and the Mathematical Resilience Scale (Kooken, et al., 2013). These are accepted through the research community as being good measures of these characteristics and have been used in several studies, for example, (Dew, et al., 1984), (Pajares & Urdan, 1996) and (Batchelor, 2016). In addition to this, Betz’s (1978) scale in particular was chosen as it could be used for university students and demonstrated a suitable number of items to gauge whether a student was MA, and how severe their anxiety was if they were.

Mathematical Resilience Scale

An adaptation of the original scale demonstrated in Johnston-Wilder et al. (2014) comprised of 23 items and was used for the questionnaire in this study. The scale comprises of three subscales, growth

(7 items), struggle (7 items) and value (9 items), which have been chosen because of their importance in the development of the concept of mathematical resilience.

A five-point Likert scale was used for the mathematics resilience scale in this research to keep it consistent with Betz's scale, which uses the same. It is also so that the findings from this research could potentially be compared against the findings of others' research such as Johnston-Wilder et al. (2014), and so that students were not overwhelmed by the number of answer options available to them. Each answer option was given a score from 1 to 5, where 1 represented Completely Disagree and 5 represented Completely Agree. Students could score a total of between 23 and 115, where the higher the score, the more resilient they were according to the scale. They could also have three individual resilience scores given by each of the subscales. The questions were also reordered to match Johnston-Wilder et al. (2014) and some questions were negatively worded; this was to ensure students did not fall into a rhythm and miss differences in wordings between questions.

Mathematical Anxiety Scale

Betz's scale comprises of 10-items aiming to determine the respondent's level of mathematical anxiety. A five-point Likert scale was used with 1 being Strongly Disagree and 5 being Strongly Agree. The highest score is therefore 50 (most mathematically anxious) and the lowest is 10 (least mathematically anxious). Unlike the MR scale, the MA scale does not have any subscales.

In this research, this scale was utilised to measure the MA levels of students of different demographic backgrounds and studying various courses for the purpose of identifying whether there was a significant difference in their base level of MA as Johnston-Wilder et al.'s (2014) study did. It was also used to measure the effectiveness of an intervention aimed at reducing MA.

The full set of items for both scales can be found in Appendix 1.

3.3.1.3 Design of the mathematical anxiety and resilience questionnaire

The purpose of the engagement questionnaire (refer to Appendix 2) was to determine reasons for student non-engagement. These answers would be investigated in more detail in the focus groups/interviews. Although some questionnaires adopt an approach of starting with close-ended questions to "ease" participants into the questionnaire, it was decided to start the engagement questionnaire with open-ended questions that had a word limit so that participants were not forced to give answers that were not entirely their own.

For example, consider a close-ended multiple response question such as:

I did not engage with mathematics and statistics support (MSS) because:

I did not know MSS existed

I did not know where MSS was

The times MSS was available were not convenient

I thought MSS was only for mathematics students

Other, please specify

This question may put ideas into participant's minds or give them easy options to tick so as to avoid having to write something in the "Other, please specify" box. Furthermore, by presenting only structural / procedural reasons respondents may, subconsciously, be directed away from giving affective reasons in the "Other" category. It was felt that open-ended questions with word limits were less leading and were more likely to reveal the participants' true feelings.

Care was taken with the design of the questionnaire to ensure participants would not be discouraged from participating by the structure, wording or length of the questionnaire.

Both questionnaires were ended by thanking participants to ensure students felt the time they had given to the questionnaire was appreciated and their responses were valued. In the anxiety and resilience questionnaire, students were signposted to the places they can access mental health support, since some students may have ended up recalling anxious experiences with mathematics whilst they were doing the questionnaire. However, care was taken to minimise this possibility through the brief wording of the questions, but the signposting was kept as a precaution since the welfare of students was of the utmost importance. Furthermore, the resilience questions were asked first so that students were not dissuaded from answering the survey by the negative tone of the anxiety questions.

The wording of the questions was tailored for the audience. Where possible, complicated language was avoided and questions were kept concise, except where elaboration was needed to ensure students could comprehend the question. An example of these considerations being made is given below. Originally, one question in the engagement questionnaire was as follows:

What would encourage you to attend ***sigma*** *more/for the first time?*

Do you have any ideas on how this may be achieved?

These were changed to:

What was your main reason for engaging with ***sigma****? (This question would only be shown if they had previously answered that they had engaged with* ***sigma****.)*

What would encourage you to engage with ***sigma****? (This question would only be shown if they had previously answered that they had not engaged with* ***sigma****.)*

The last part of the question was asked separately to all participants and reworded to:

*Do you have any ideas of how to encourage more students to use **sigma**'s services?*

As well as avoiding asking longwinded questions, the question wording also did not direct the student to answering in a specific way.

Overall, multiple revisions were made to the questions and the order of them before they were published to ensure that the questionnaire followed the principles set out in (AAPOR, 2021), specifically that double-negatives, double-barrelled, leading questions and complex language was avoided.

The questionnaire was also discussed with and completed by non-participants to determine whether it could be considered a reliable method to obtain data.

In addition to question wording, the types of questions used in the questionnaires were also varied. A mixture of close-ended, open-ended and scale questions were used to optimise the value of responses achieved from the participants and to extract different types of information from the students.

A five-point Likert scale was used for all scale questions. A neutral option was included as a "neither agree nor disagree" so participants did not feel pressured into giving a response, though a concern was raised that participants would go for this "easy" option to avoid answering.

Open-ended questions were also used to gauge students' attitudes and gain an insight into their personal experience with **sigma**. Though these questions can yield rich data, the response rate tends to be lower than other types of questions because these questions ask students to expend more effort on their answers which may deter them from answering at all.

To ensure enough data was retrieved from students in lieu of this, close-ended questions were used to extract specific information. These were not used often in case there was not an option which students felt fit them, and alternative ranking questions were used, where students ranked options according to how important they felt it was in context of the question (question 14 in Appendix 2 is an example of this).

3.3.1.4 Delivery of questionnaire

The questionnaire was first piloted with a Computer Science student. Appropriate changes were made where necessary to avoid ambiguity, including to the opening and closing statement of the questionnaire.

3.3.1.5 Advertising

Students were invited to participate in the resilience questionnaire on completion of their diagnostic test, a mathematics test given to Coventry University students upon their enrolment. Initially, the link was straight from the diagnostic test but that later this had to change because of software changes. Students were then either emailed or messaged over Microsoft Teams if they agreed to be contacted further to participate in the other questionnaires, intervention or focus group. Follow up emails and messages were sent in case students had not seen the original email, especially since online teaching meant they were more likely to have an influx of emails from their own course leaders.

The questionnaire was advertised to students through cooperating module leaders, their Aula noticeboard (Coventry University's online learning platform), email and Microsoft Teams as these were methods approved by the University for the collection of data. Once in-person classes resumed, the questionnaire was also delivered to students in the physical **sigma** centre and during lecture times.

3.3.1.6 Analysis

Quantitative data was analysed using statistical software SPSS and/or R whilst qualitative data was analysed using the six-steps of thematic analysis (Braun & Clarke, 2006, p. 87) or general inductive approach (Thomas, 2006).

Either the inductive or deductive method can be used to analyse qualitative data, as described below.

Inductive Approach

The inductive approach involves developing codes organically from the data, without any preconceived ideas about the codes that may emerge.

Deductive approach

The deductive approach of analysing interview data differs due to the fact that coding categories are created before any analysis is conducted. The data will then be categorised according to these predetermined themes. This approach can be used to sort data into organisational categories, especially with the aim of keeping data aligned with research questions. It can also be used when wanting to apply theoretical or conceptual frameworks (Bingham & Witkowsky, 2022).

3.3.2 Interviews

Interviews can produce much richer data for qualitative analysis compared to questionnaires, particularly when discussion around respondents' opinions and experiences may be beneficial (Denscombe, 2007). They can be used as the only method of data collection for qualitative research, but they are often be used in conjunction with other methods of data collection – such as questionnaires – to much success (Adams & Cox, 2008). They can be delivered either online or face-to-face, where cues from respondents' body language can also be commented on.

3.3.2.1 Advantages and disadvantages

Interviews are an established method for gathering rich data, particularly in the context of exploring respondents' attitudes, emotions and experiences. However, they are considerably more time-consuming than other methods of data collection, such as questionnaires. They require some level of training on the interviewer's part and require the interviewer to have skills that lend themselves to making respondents feel at ease, such as being friendly, forthcoming, and responsive. If certain standards are not met, there is a high risk of bias occurring, potentially as a result of irrelevant or inadequate points of inquiry or even informality. Some respondents may also be concerned about the lack of anonymity with interviews (Bailey, 1994).

3.3.2.2 Good practice

It is important to be flexible when setting the time and place of interviews, but also to take into consideration the timing that is most appropriate to get productive answers. Holding an interview late at night when a respondent is tired would not be conducive to having a worthwhile interview, for example. Respondents must also have a clear understanding of the purpose of the interview as they would in all forms of overt research, which can most commonly be achieved through a participant information sheet. Consent must also be obtained, either written or digital, particularly if the interview will be recorded.

During the interview, respondents should be reminded not only of the purpose of the interview, but also of the importance of their participation, and their rights regarding withdrawing from the research. The questions and the order in which the questions will possibly be asked should also be memorised so that awkward pauses can be avoided and there is a natural flow to the interview (University Writing Center, 2014). Finally, the person should be thanked for their participation and directed to any appropriate resources, particularly if sensitive topics have been discussed.

The interview should be transcribed as quickly as possible, or alternatively, notes should be checked to ensure they are complete (University Writing Center, 2014). It is also good practice to email the participant again to convey thanks – if the findings of the research would be of interest to them, any publication outcomes from the interview may also be attached.

Action can be taken to avoid interviewer bias, such as turning off the researcher's camera in an attempt not to unduly influence the response given during online interviews; smiling or nodding excessively may prompt a certain response from the interviewee. However, before the interview is conducted, it may be worthwhile to have a short face-to-face conversation to ease students into having an open conversation. In any follow-up questions posed, care should continually be taken not to ask any 'leading' questions and guide the respondent into agreeing with the researcher's views.

Further to this, it is important to develop a relationship with the respondent so that they feel comfortable discussing potentially sensitive topics, such as mathematics anxiety. It can also help students divulge further relevant information around their experience without prompting. Being an attentive and active listener also contributes to this significantly, and is perhaps the most important skill an interviewer can develop. Honing this skill ensures that an interviewer is conscious of not only what the respondent is saying, but also of what questions can be asked to elucidate their experience further.

The skills of an interviewer can be developed by appropriate training and practice and conducting a pilot interview before the main study can be productive as it may highlight inconsistencies in the questions.

3.3.2.3 Structure

There are three different methods of delivering interviews: unstructured, semi-structured and structured. Unstructured interviews need the least level of preparation since there are no set questions to be asked and neither is there any formality around the interview discussion. On the other hand, both semi-structured and structured interviews, as the name suggests, need some level of question preparation. Semi-structured interviews provide more flexibility of discussion, with the interview questions being more a guide for conversation than strict boundaries.

Structured interviews have predetermined questions, and these are asked in the same order to all participants. There is also not much scope to ask follow-up questions to review a response further, but this means analysis is potentially more straightforward, since question response can more easily be compared.

Unstructured interviews are associated with a higher risk of bias, and their nature also means response comparisons across questions is difficult to manage. However, they do have the potential to generate a strong response around a particular topic.

Semi-structured interviews capitalise on the strengths of both other interview types, with the structure allowing relative ease of analysis, whilst also allowing for some flexibility in both the wording, timing and addition of questions.

3.3.2.4 Type of questions

As evident from the previous subsection, questions must be decided upon before the interview, except in the case of unstructured interviews. Either open or closed questions can be used, each for differing purposes.

Close-ended questions

Close-ended questions are when the researcher poses a question and usually provides pre-set response options for the participant (Creswell, 2012). These are used to determine facts and can influence the direction of the interview. Whilst these types of questions provide limited information, they are easy to compare and analyse. An example of this type of question is,

*Have you ever visited **sigma**?*

A neutral question such as this is best to begin an interview with so as to help ease respondents into exchanging information freely for the subsequent questions.

Open-ended questions

Open-ended questions are questions for which researchers do not provide the response options (Creswell, 2012). These are used to determine opinions or attitudes of respondents and give no direction to the participant about how they should answer. Although these questions can provide meaningful information, they are much more time-consuming to analyse. An example is,

How did you feel about mathematics at school?

3.3.2.5 Interview guide

The predetermined questions as well as talking prompts and a proposed structure for the interview can be compiled into an interview guide. This ensures some modicum of structure to the interview and also consistency in the delivery, especially if it is a structured or semi-structured interview. It is also useful to have before seeking ethical approval since any adjustments deemed necessary by the ethics board can be made well in advance of delivering the interviews.

3.3.2.6 Analysis

The analysis of interviews may differ according to the means used to collect information from the interview; it may have been audio-recorded or notes may have manually been taken. Researchers may also opt to video-record the participants so that they can take note of facial expressions, any indications of unease, or even confusion.

Subject to the number of interviews, interviews can be transcribed and analysed by hand, or through the use of software such as NVivo. Both methods use a similar approach in organising the data and subsequently "coding" it, and it is up to the user to decide on whether an inductive or deductive approach is used to analyse the qualitative data (Canary, 2019) as discussed above.

Both methods of analysing the data showcase their own benefits, with the inductive approach producing more nuanced findings, whilst any deductive analyses highlight themes that are essential to the research. This is particularly useful when the interviews are conducted to provide further reflection on already identified themes in the research area. An overview of the primary data collection methods discussed can be found in the following table.

Table 3.4

Overview of data collection methods

Data collection method	Design	Analysis	Advantages	Disadvantages
Questionnaires	Type, order and response categories used	Dependent on type of question. Statistical analysis or qualitative analysis	Cost and time effective	Unable to ask for clarification if needed
Interviews	Structure of interview and interview guide	Qualitative analysis on open-ended questions	Rich source of data	Time-consuming Subjective

3.3.2.7 Usage of interviews in this study

Semi-structured interviews were used to further investigate responses submitted by some participants to the engagement questionnaire. A core reason for following up the questionnaire with interviews was to determine whether the responses given in the questionnaire aligned with what students shared in the interviews, particularly around whether affective reasons were given for non-engagement, as the researcher believed students would be more likely to disclose these reasons during the interview rather than the questionnaire. Initially, a mixture of interviews and focus groups were to be delivered, but due to difficulties with data collection, it was decided that semi-structured interviews would be sufficient.

3.3.2.8 Design

Semi-structured interviews were used to allow some degree of flexibility in the order and wording of the questions and so that the flow of the interview was not damaged by rigid structuring.

Type of questions

It was decided to use a majority of open-ended questions since brief data had already been gathered through the engagement questionnaire and the purpose of the interview was to delve deeper into students' reasons for their level of engagement. However, to ease respondents into the interview and to first determine whether students had engaged or not engaged with **sigma**, the first question asked was kept close-ended and simple:

*Have you used **sigma** before?*

This gave the interviewer information on how the interview should be directed, since variations of subsequent questions were used contingent on whether a student had visited **sigma** yet.

The content of the interview was informed by the literature, and a litany of different sets of questions emerged from this, primarily focusing on mathematics anxiety, student perception of mathematics and statistics support, their attitudes about mathematics, and most importantly, their own underlying reasons for their level of engagement. The student's MA and MR scores were not known before the interview or the analysis. This was matched when the resilience questionnaire was analysed. When the attendance data was analysed, students' answers were cross-checked to determine if they had in fact engaged with **sigma**.

The remaining questions were open-ended to maximise the amount of valuable data gathered from students – these can be found in Appendix 5.

Although it is known that an independent interviewer may be better suited to delivering the interviews, the researcher thought it would be impractical to offload this responsibility onto another because of the time and dedication it would require. The researcher did not have prior experience with interviewing, so care was taken to follow the guidelines set for interviewers as aforementioned.

3.3.2.9 Delivery

It was decided that the interviews would be delivered online via Microsoft Teams as this is the platform most used at Coventry University. Conducting the interviews online was initially necessary due to the government guidelines in place for the pandemic. Later, to accommodate both for the researcher and for students, it was decided that interviews would continue to be held online. The availability of students was taken into account when arranging the time for the interviews. Due to the time constraints of the research, the time difference between a student answering the questionnaire and participating in the interview differed from a week to a few months, although this did not have any bearing on the method in which the interview was delivered. No reference to the questionnaire was made during the interview to ensure students did not feel forced to give certain answers.

3.3.2.10 Advertising

A question was added to the engagement survey asking whether a student would be willing to be contacted by the researcher to participate in the interview. Those who agreed were emailed and/or messaged on MS Teams with details about the interview, their rights as a participant, along with the participant information sheet and informed consent form.

Social media sites were also used for recruitment, such as Twitter and LinkedIn, although these methods did not appear to be successful in attracting students.

3.3.2.11 Analysis

The interviews were recorded and transcribed using MS Teams. The transcript produced by Teams contained inaccuracies, so these were manually corrected by the researcher by viewing the recordings again. The transcripts were produced prior to any analysis and stored in OneDrive for data protection reasons. These transcripts were anonymised and deleted once analysis was complete as this was the agreement the researcher had made with the University's Research Ethics Committee.

Due to the quantity of data produced, it was decided that NVivo would be used for the analysis process, primarily for the categorisation of the responses into 'codes' and to explore any relationships that may arise using thematic analysis.

Thematic analysis is seen as a foundational method for analysis and is not set within a specific epistemology so can, and is, usually used as an analytic tool in research. Braun & Clark (2006) detailed a six-step guide on how to analyse qualitative data sets through thematic analysis. The analysis begins with becoming familiar with the data gathered until overarching themes become apparent. Preliminary codes are assigned to the data to achieve this. From here, common themes can be identified and reviewed before being finalised. This method is used to identify and understand key themes in the data.

How the steps described in Braun and Clark (2006) about thematic analysis were used for analysing interview data inductively in this research is now demonstrated.

Step One: Familiarising yourself with your data – The data was transcribed using Microsoft Teams, with the researcher rereading the transcripts to correct any errors. Initial views on the data were noted.

Step Two: Generating initial codes – NVivo was used to assign initial codes to the data. The interviews were coded in consecutive order, with all relevant information added to the codes created.

Step Three: Searching for themes – The codes were reviewed, with related ones collated to create themes.

Step Four: Reviewing themes – The themes were re-evaluated to check if both the coded extracts and chosen themes represented the dataset well.

Step Five: Defining and naming themes - The themes were investigated in more detail at this stage so as to understand them in relation to the data and identify why these themes had been selected, as well as to ensure they were accurate in name.

Step Six: Producing the report – Extracts were chosen from the data to be discussed in the report (in this case, the relevant chapters of this thesis). These extracts were selected after careful analysis of all the data coded within each theme so the report was both representative and compelling in its narrative. The argument was kept balanced and all analysis was related back to the research questions the interview aimed to answer.

Where needed, whole sentences were coded together to give the researcher a clear picture of what exactly was meant to be conveyed, particularly since English was not the first language of some respondents, and also because it is common for dialogue to not always be linear. This meant respondents' narratives and personal stories could also be captured to fully gauge what impacted their engagement with support.

Once a list of codes had been generated, it was clearer to see which could be grouped together into common themes.

3.3.2.12 Conclusion

Interviews were held with students of different ages and backgrounds to further investigate their reasons for engagement/non-engagement with mathematics and statistics support. Appropriate measures were taken and advice was sought from experienced researchers to avoid bias. Question wording was revised and the interviewer's camera was turned off so as to stop any unconscious cues from the interviewer on what response was wanted or expected. The method meant the responses given to the engagement questionnaire could be elaborated on, and in some instances, provided new avenues of exploration.

3.3.3 Intervention

An intervention was developed with the aim of increasing participants' mathematical resilience. The concepts of MA and MR were explained to students, and students were asked if they could recall a time where they felt "afraid" of mathematics without realising. The hand-model of the brain (Siegel, 2010) was also shared with them to explain how mathematics anxiety impacts the logical part of the brain, and how this may interrupt cognitive processes. This led to the sharing of what techniques could be used to override this "fight-or-flight" response. The Growth Zone model and the Ladder model (Johnston-Wilder, 2018) showed students how essential it was to feel safe enough to ask for help.

Initially, five one-hour sessions were to be held with students, but after piloting the intervention, this was reduced to three one-hour sessions since it was found that having smaller groups (usually under 5 students) meant less time was needed to hear student responses. Due to the pandemic, some sessions were delivered online over Microsoft Teams, whilst some were held in-person during lecture time.

Modifications were also made to be able to deliver the intervention in one-hour due to constraints on students' availability. Another reason for any time adjustments made was to accommodate and be considerate to those lecturers who shared their class time for the delivery of this intervention and stayed during the session.

3.3.3.1 Measurements

Participants were asked to complete the mathematics anxiety and resilience questionnaire before and after the delivery of the intervention. The MA and MR scores of students were used as one measure of whether the intervention had been effective. Additional questions were added to the end of the questionnaire to receive feedback on the intervention, as it was believed just responding to the previous questions would not give an in-depth understanding of the benefits and shortcomings of the intervention.

In the final session of the intervention, students were also asked for feedback on the intervention. The questions asked revolved around what perceived benefits they found with the intervention, any improvements that could be made, and about their perception of **sigma** before and after the intervention. This question was also briefly discussed in the "Mathematics Engagement" questionnaire, though it was repeated at the end of the intervention to understand any potential impacts of the intervention on how **sigma** was seen by students.

3.3.3.2 Sample

Students were recruited for the pilot of the intervention primarily through the resilience questionnaire. In that questionnaire, they were given the option of being contacted again. Those that agreed were emailed and then messaged over Microsoft Teams if emailing them did not produce a response. Students attending **sigma** were also told about the questionnaires when they were in the queue for seeking support from staff, with one of the questions being about being contacted for participation in the intervention. Module leaders, in particular, from Computer Science, Biosciences and Engineering, also shared information about the intervention with their students. Further to this, students who took part in the intervention shared details of it with their peers because they believed it may be beneficial to them.

3.3.3.3 Pilot

An intervention was piloted with a Computer Science student to determine its effectiveness. Subsequently, changes were made to the structure of the intervention and to its content. One example of this was when students expressed their interest in the techniques that could be used to control mathematics anxiety soon in the first session. This had been planned to be discussed in the third session but after hearing this, it was moved to the first session. This was adjusted on the lesson plans as it made more sense to equip students sooner so their experiences with the tools given could be discussed in further sessions.

The sessions also took less time than expected, so rather than one-hour sessions, they were reduced to being forty-five minutes. This was to ensure students would not be overwhelmed by information, and they could try implementing the techniques they learnt during that session before their next session, where the impact of the techniques used could be discussed.

3.3.3.4 Analysis

General Inductive Analysis (Thomas, 2006) was used to evaluate the qualitative feedback students gave after the intervention. The aim of GIA is to develop categories from the data to answer "what are the core meanings evident in the text, relevant to evaluation or research objectives" (p.241). It was felt that this was sufficient (rather than a full-scale thematic analysis) since each item in the dataset was short (not the transcript of an hour long interview) and focused on responding to a relatively narrow question. First, the data must be cleaned, and then read with close attention to detail so that categories may be formed. Text may be coded into more than one category unlike other quantitative coding techniques. Categories must then be revised, and can be amalgamated under a main category. This was followed to ensure a thorough evaluation of the responses received.

3.3.4 Attendance data

2018/19 and 2020/21 secondary **sigma** attendance data was matched through student ID numbers to obtain student demographic and course information. Attendance data is tracked by the centre by asking all students to scan their student ID card upon arrival or input their details into the reception computer. Students that visit the online drop-in centre input their details before being admitted into the BigBlueButton room where the drop-in support is hosted. There are some potential measurement errors since some students may forget to swipe their card when using the face-to-face support, or enter their details multiple times if they visit the centre again in the same day. This is less of a concern with the online support, but occasionally, some students may enter inaccurate details.

The data obtained from the University include student's academic year, ethnicity, age, gender, entry qualifications and disability status.

Descriptive statistics were used to provide an overview of the data, whilst the hurdle model, t-tests, the ANCOVA model and the Poisson model (an explanation will be provided in Chapters 4, 5, 6 respectively), were used for more in-depth analysis. A combination of SPSS and R was used to run these tests. More explanation on these tests can be found in Chapter 4 when they are used.

The findings of this quantitative analysis will be compared to the findings of the qualitative analysis to determine whether they are in agreement or if more data collection or analysis is required. The data from these two academic years was chosen so a comparative analysis of pre-pandemic and pandemic usage of the centre could be drawn.

The following subsection will explain the rationale for each research question, together with the methodology that was chosen to answer it. For clarity, the research questions are repeated.

3.4 Research Questions methodology

The way in which the recommendations will arise from the research questions is now detailed, as well as a brief explanation of the methodologies used.

RQ1) How do student characteristics affect student engagement with MSS?

To answer this question, secondary data provided by the University on MSS attendance data for the academic years of 2018/19 and 2021/22 was analysed alongside student demographic data and course data. This was to ascertain the typical users of MSS, separated into course groups and demographic factors. By doing so, some clarity can be gathered on whether specific student groups may benefit from targeted interventions to increase student engagement and thereby attainment. Ní Fhloinn et al.

(2016), Dzator and Dzator (2018) and Edwards and Carroll (2018) investigated varying demographic characteristics (gender and age respectively) with respect to engagement with or impact on MSS using quantitative analysis through SPSS (such as chi-squared tests and regressions where appropriate). Therefore, it was decided similar methods would be used, namely, in SPSS and R, to further determine any relationships that existed between characteristics.

RQ2) What effect, if any, do MA and/or MR have on student engagement with MSS?

Since quantitative analysis of secondary usage data only provides some insight into engagement, it was further decided that investigation into factors that can typically affect engagement with mathematics would be considered. Namely, the factors of MA and MR were considered for their effect on engagement with MSS because MA has known inhibitory effects on engagement with mathematics, whilst the construct of MR contains attributes needed in order to be engaged with mathematics (Lee and Johnston-Wilder, 2017). Thus high levels of MR may be associated with higher engagement with MSS. The question was answered through the delivery of a mathematical anxiety and mathematics resilience (MAMR) questionnaire to students with the aim of determining their level of MA and MR. This primary data was then matched to attendance data to discover whether individual students had visited the MSS drop-in support. This was carried out with the data from two academic years, 2020/21 and 2021/22. As most questions were Likert scale questions and this was an established scale, statistical analysis through SPSS was used as is recommended.

RQ3) What is the effect, if any, of developing students' levels of MR on their engagement with MSS?

It was important to determine whether a relationship existed between MA and MR score, students' course, demographic characteristics and level of mathematics required for their selected course. This would provide further insight into whether specific groups of students were at potentially significant risk of being highly MA. If this is found to be the case, universities could target these groups to remedy MA that was impacting on their engagement. This was achieved through using University records again and matching it to the MAMR questionnaire data.

As mentioned above, MR may mitigate the harmful effects of MA on student attainment in mathematics and increase engagement with the subject. It was therefore deemed an interesting avenue to explore regarding whether an intervention aiming to increase MR levels in students would extend to also increasing student engagement with MSS. Resources from Johnston-Wilder (2018) and Johnston-Wilder (2020) were partially modified to adapt to university students, and changes in MA and MR levels were monitored through the delivery of the MAMR questionnaires prior to and after the intervention. Analysis was again run in SPSS. Qualitative feedback was summarised rather than thematically analysed since responses were few, although the initial plan had been to use thematic analysis.

RQ4) How do students explain their level of engagement with MSS?

A common concern for those involved with the delivery of MSS is how to increase student engagement. Studies dedicated to finding the underlying reasons for non-engagement (O'Sullivan et al., 2014; Symonds et al., 2008) discovered many students attributed their non-engagement to structural reasons, such as lack of awareness of the services or unsuitable timetables. These studies used practices such as close-ended questionnaires and on-the-spot interviews to collect student responses. Due to the nature of the topic, it was believed students may be unwilling to disclose affective reasons for their non-engagement, particularly to those they may see as "staff", and so may have responded by giving "more acceptable" responses as an explanation. Therefore, it was decided that both an engagement questionnaire and individual interviews may be more insightful in discovering student reasons for non-engagement, and in particular, whether students gave the same responses for their level of engagement in the questionnaire as in the more in-depth and personal interview. Thematic analysis was used to analyse open-ended questions due to the flexible approach it offers when analysing large sets of data, as well as its relative ease. Furthermore, categories do not need to be set up in advance for this method, meaning the data itself leads to the emergence of themes, which, for this question was the aim. Pre-categories had been used in previous research, so more freedom was wanted in both the responses and in the analysis.

The findings from each of the questions were combined to create recommendations for future practice for practitioners aiming to increase student engagement with their services.

A summary of the associated methodology for the research questions now follows.

Table 3.5

Research questions and associated methodology design and techniques

Research questions	Type of data	Logic of inquiry	Analysis	How do recommendations arise?
RQ1) How do student characteristics affect student engagement with MSS?	Secondary **sigma** attendance data University-held data on students' course of study, demographics and characteristics	Deductive	Quantitative data analysis – statistical analysis	Through statistical analysis and inference in R and SPSS /Suggestions from literature
RQ2) What effect, if any, do MA and/or MR have on student engagement with MSS?	Primary MAMR questionnaires (questions from established scales), Secondary data used to answer RQ1	Deductive	Quantitative data analysis – statistical analysis	Through statistical analysis and inference in R and SPSS /Suggestions from literature
RQ3) What is the effect, if any, of developing students' levels of MR on their engagement with MSS?	Primary MAMR questionnaires (questions from established scales), Secondary data used to answer RQ1, Primary feedback questions	Inductive Deductive	Quantitative data analysis – statistical analysis, Qualitative data – general inductive analysis	Through statistical analysis and inference in SPSS, Qualitative feedback – noteworthy comments
RQ4) How do students explain their level of engagement with MSS?	Primary engagement questionnaires, Interviews, Secondary data used to answer RQ1	Inductive	Qualitative data analysis – thematic analysis	Common themes, Noteworthy comments

3.5 Ethical considerations

Ethical approval was obtained from the University to collect the data required and to deliver the intervention. In particular, advice was sought from the Information Governance Unit about the procuring of sensitive data such as disability and ethnicity. Following the advice, "Data Protection Impact Assessment" and "Legitimate Use of Student Data Analytics" forms were attached to the appropriate ethical approval submission form. Further to this, it was noted that participants have a right to be completely informed of the details of the research study (whether they are participating in a blind study or not). Since there was not a great concern that participants would be influenced by any of the information they received, students received full details of what the study entailed. The aims, potential risks and potential benefits of the research were clearly explained to participants in the appropriate participant information sheet. Electronic signatures or typing of one's name was used to sign the consent forms for the intervention. It was decided that electronic signatures would not be necessary to consent to participation; this was to allow for students that may not have access to devices that enable them to do this. The consent forms for the questionnaire were incorporated into the survey, which was delivered online. Students were made to answer a compulsory question, which asked whether they gave their consent to proceed. The responses of any students who did not consent were not included in any analysis. Students were also made to confirm that they had read the participant information sheet. (Examples of the Participant Information sheet and consent form can be found in Appendices 3 and 4.)

It was of paramount importance to keep all data confidential, particularly since sensitive topics such as anxiety were being discussed. The data was also anonymised as soon as feasible. Furthermore, if data was not kept anonymously, students may have been concerned that either **sigma** or their lecturers knew what they had disclosed, especially if they were speaking negatively about either. It ensured students felt comfortable being honest in their answers. It was also decided that pseudonyms would be used for students participating in the intervention and interviews, such as Respondent 1, 2, etc., Numbers were used rather than actual names to avoid the risk of giving "clues" as to the actual identity of the students, such as their demographic background.

3.6 Summary

This chapter has provided an insight into the research methodology chosen, and the justification for why it was chosen. The research questions informed the direction this research would take, and thus, it was decided that a mixed methods approach would be used. This was followed by a discussion of questionnaires and interviews as a means of collecting data, and the delivery of an intervention. The end of this chapter highlighted the ethical procedures followed to ensure best practice.

4 The effect of student demographic characteristics on engagement with MSS

4.1 Introduction

This chapter outlines the analysis of **sigma** attendance data for the academic years of 2018/19 and 2020/21. One purpose of this is to compare engagement with MSS before the pandemic and during it, and as such, face-to-face and online support.

There are two types of data considered in this chapter to create user profiles for engaged students:

- Raw **sigma** attendance data for the two academic years which only monitors the visits made to the drop-in support
- University data to provide context to the visits made in terms of providing detail about how many students in particular courses or demographic groups choose not to engage.

Furthermore, two main measures of engagement are investigated herein, the first of which is whether a student has engaged with **sigma** at least once, and the second is the number of visits once they have engaged. From this point, students engaging at least once will be referred to as students who engaged, whilst those who have visited more than once will be known as students who engaged repeatedly. Whilst the first provides insight into the difference between those who engage and do not engage, the second provides an understanding of those that choose to re-engage, which has yet to be investigated in relation to demographic characteristics.

The primary aim of this analysis is to gain insight into the issue of non-engagement with MSS by combining both datasets. This chapter first states the core research questions that aim to be answered by the study, then gives an overview of the dataset analysed. This is followed by the model chosen to identify predictors of engagement and repeat engagement with **sigma**, the analysis of the data, and a discussion and summary of key research findings.

The research question this aims to answer is:

RQ1) How do student characteristics affect student engagement with MSS?

The sub-research questions for this chapter are listed below.

SRQ1) What proportion of students engage with sigma?

SRQ2) What is the student profile of those who engage with sigma?

SRQ3) Conversely, what is the student profile of those that do not engage with sigma?

SRQ4) What effect do varying demographic characteristics have on whether or not a student engages and, if they do, how often they engage?

4.2 Attendance data from 2018/19

4.2.1 Sample

In the academic year of 2018/19, 15677 total visits were made to **sigma** by 3594 individual visitors in the university. A large majority, 70%, of the total number of visits were made by students from one of nine groups of cognate courses; henceforth, these course groups are referred to as "collective courses". For example, the mathematics and mathematics and statistics courses are grouped together under the umbrella of mathematics. Students from the nine collective courses made up almost 50% of the unique visitors. Therefore, for ease of analysis, these courses were considered to provide a sufficient sample size to analyse, and demographic and course data was obtained for these students. Additionally, data from students on Computer Science, Biomedical Science and Psychology courses were also added to the dataset because of the relatively high mathematical/statistical content and the typically low interaction these students had with **sigma**. This gave 7193 students in total on the 12 courses considered in this analysis, with 4856 enrolled in the top nine courses, and 2337 in the other three courses.

4.2.2 Cohorts

4856 students were enrolled on the top nine collective courses by total number of visits; of these 1792 visited **sigma**. This gives that approximately 37% of students from these collective courses chose to engage with MSS. In Biomedical Science, Psychology and Computer Science, 2337 students were enrolled, with 157 of these students visiting **sigma**. Only 7% of students from these collective courses engaged with MSS. This gives that in the 12 collective courses analysed, 27% of students engaged, showing that Computer Science, Biomedical Science and Psychology students engage less comparative to the other nine collective courses.

The mean number of visits per student was 1.51, whilst the standard deviation was 6.65. Outlier values were calculated to be over 18 visits by calculating what number lay 2.5 standard deviations away from the mean value of visits. 146 of the students had visited over 18 times. A one sample t-test was conducted to determine whether these outlier non-erroneous values significantly affected the analysis. The test value used was 1.51, the mean of student visits to **sigma** when outlier values were included. For clarity, the mean number of visits with no outlier values was .72, showing the mean changed from having an average of over one visit (so the average student did engage at least once) to a value under one; therefore, on average, seven in ten students will engage once according to this mean. As expected from the mean values, the test showed outlier values did significantly affect the analysis, $t\ (7046) = -32.76$, $p < .001$. Thus, these values were removed so that the mean was more representative of the dataset. This meant students who visited **sigma** inordinately more than the general student population were not included in the analysis. However, it does provide some insight into the behaviour of students in that some may use the centre often to work socially, explaining their higher number of visits.

4.2.3 Gender

Across the final dataset of 7047 students that could have visited the centre during the academic year 2018/19, 38% of students are female, as can be seen in Table 4.1.

Table 4.1

Total number of students in the dataset, percentage of engagement, and average number of visits made to sigma per student, broken down by gender

Variable	Total	Male	Female
Number of students	7047	4314	2733
Number of unique visitors	1803	1174	629
Total number of visits	5045	3470	1575
% of students who visit at least once	26.07	28.00	23.02
Average number of visits per student who visits at least once	2.80	2.96	2.50
Average number of visits per student	0.716	0.804	0.576

When looking at just the absolute number of visitors and visits made to **sigma** in 2018 as provided by the **sigma** attendance data, it seems that male students engage approximately two times more than female students. However, this difference is not quite so notable when accounting for the absolute number of students by gender in this dataset, reinforcing the importance of providing context for the attendance data numbers. 28% of male students engaged with **sigma** whilst only 23% of female students did. A similar trend was seen for the average number of visits made by these students, with male students having a slightly higher average, though the difference is not large. This indicates that there is not a notable difference in engagement or in repeated engagement by gender in contrast with what has been reported in the literature (Ni Fhoinn et al., 2016). It could also be that gender itself does not impact engagement or repeated engagement, but its interaction with other factors, does. Course is now discussed to see if there is any weight to this supposition.

4.2.4 Course

In the following table, courses have been amalgamated according to their mathematics entry requirements. Courses such as Mathematics and Mechanical Engineering require a mathematics A level qualification (or equivalent), whilst for courses such as Civil Engineering, an A level in mathematics (or equivalent) is only recommended. Entry to other courses such as Adult Nursing and Bioscience requires no mathematics A level.

Table 4.2

Number of students, visitors and visits made to sigma by course groups

Course Type	Students	Visitors	Visits	Percentage engaged	Average visits
No mathematics A level requirement	4089	771	1490	18.86	1.93
Mathematics A level recommended	1381	371	1141	26.86	3.08
Mathematics A level required	1577	661	2414	41.92	3.65
Total	7047	1803	5045	25.59	2.80

It is clear to see that students on courses with A level Mathematics required or recommended engage at a higher rate than those on courses with no requirement. This may be because they are studying more advanced mathematics and require more help, or it may be that there is more visibility on the services MSS provides to students on these courses. Another plausible explanation is that courses with no entry A level Mathematics requirement have less mathematical content overall and thus, there is less content to need help on. Alternatively, those studying courses with no mathematics requirement may be more averse to seeking support for a myriad of reasons, such as MA, which will be discussed in a later chapter.

4.2.5 Course and gender

Since there did not seem to be a difference in engagement overall by gender, this has been unpacked further to uncover whether there is a difference in engagement by gender in each course. A summary of pertinent information can be found in the following table, with the subsequent graphs displaying subsets of the table. Course titles have been abbreviated.

Table 4.3

Number of students split by course, gender, engagement and average number of visits made to sigma

Course	Total	Male	Female	Male visitors	Female visitors	Male visits	Female visits	% engaged (male)	% engaged (female)	Average visits (male)	Average visits (female)
Mech	845	768	77	306	33	860	88	39.84	42.86	2.81	2.67
Motor	179	172	7	72	2	171	11	41.86	28.57	2.38	5.5
Auto	350	331	19	119	6	295	24	35.95	31.58	2.48	4
Civil	739	624	115	159	25	551	74	25.48	21.74	3.47	2.96
Aero	199	183	16	53	6	105	32	28.96	37.5	1.98	5.33
Maths	183	122	61	88	50	584	426	72.13	81.97	4.79	8.52
Ac & Fi	1163	632	531	202	258	436	463	31.96	48.59	2.16	1.79
Econ	463	368	95	91	22	276	58	24.73	23.16	3.03	2.64
Biomed	1071	360	711	15	63	29	121	4.17	8.86	1.93	1.92
Nursing	591	31	560	5	145	7	222	16.13	25.89	1.4	1.53
ComSci	675	607	68	61	13	152	42	10.05	19.12	2.49	3.23
Psych	589	116	473	3	6	4	14	2.59	1.27	1.33	2.33
Total	7047	4314	2733	1174	629	3470	1575	27.21	23.02	2.96	2.50

This data is displayed through a number of graphs below, the first being the gender breakdown of the courses.

Figure 4.1

Number of students in all 12 collective courses in 2018/19 by gender

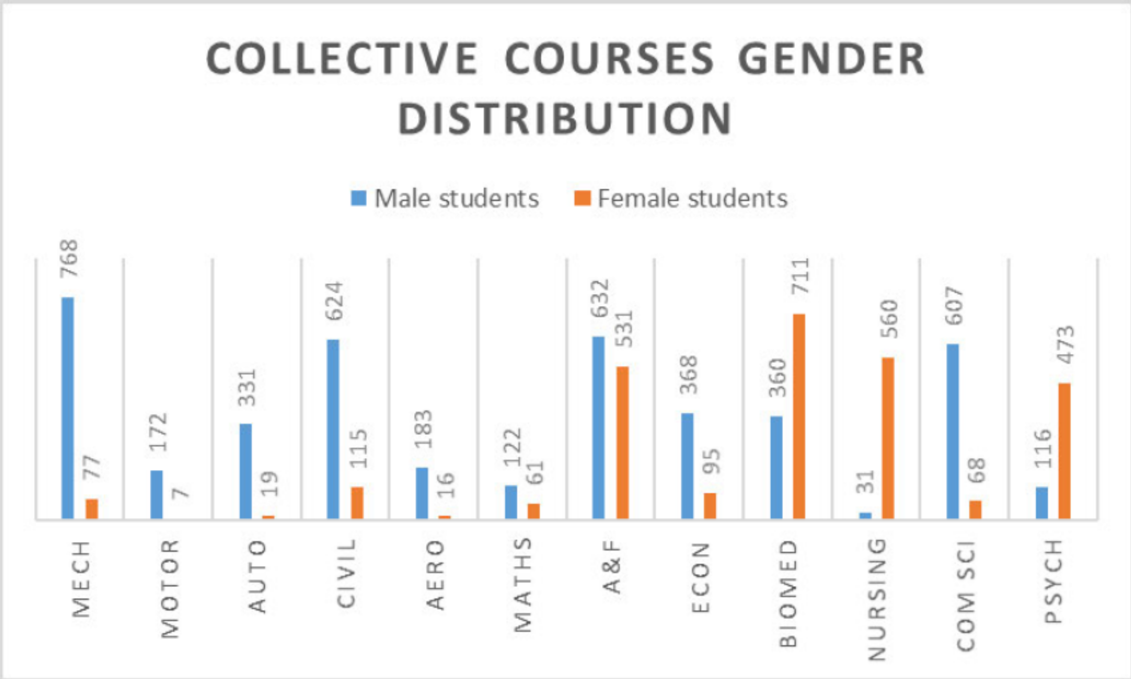


Figure 4.2

Number of visitors engaged with sigma by gender in 2018/19

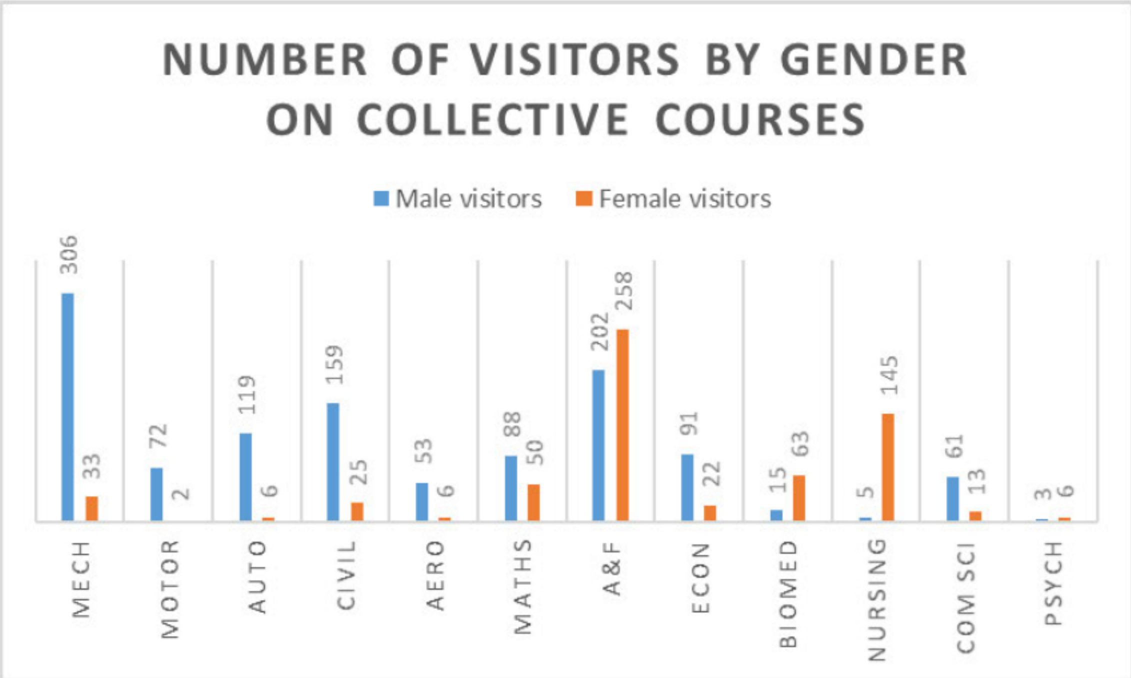
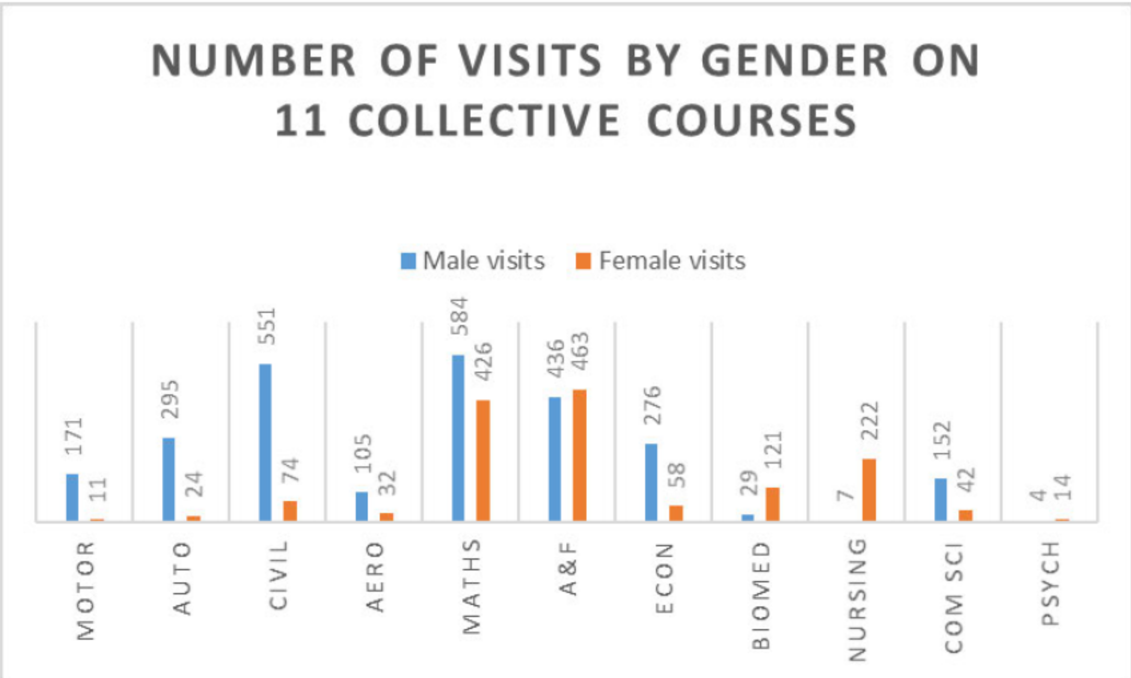


Figure 4.3

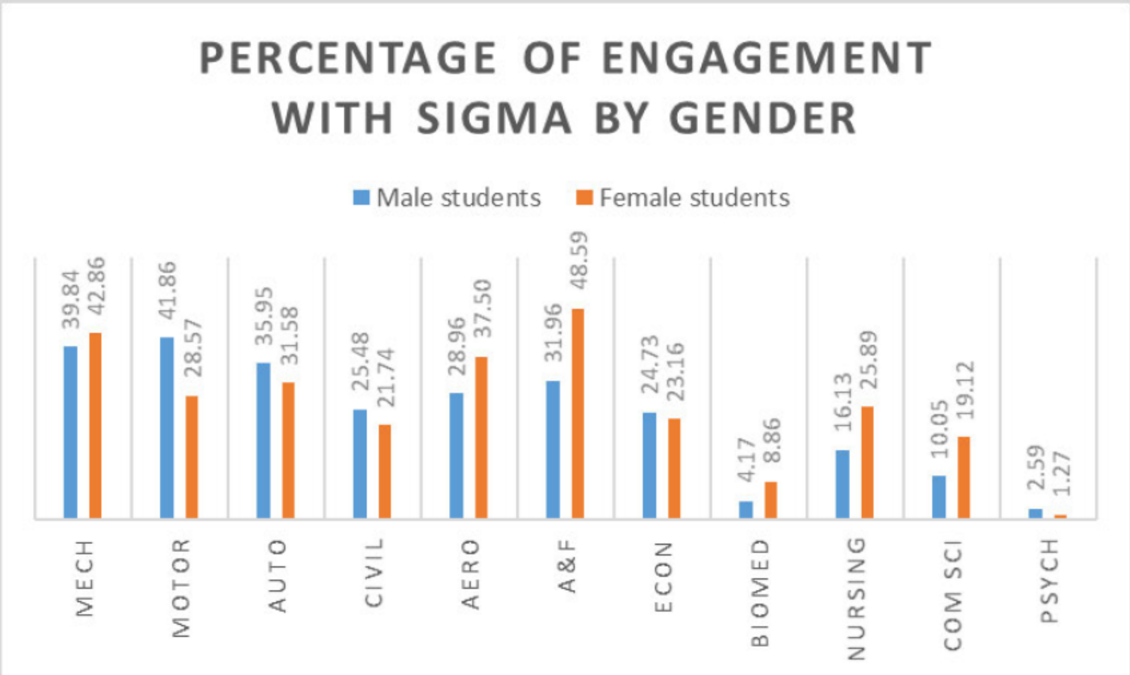
Number of visits made to sigma by students from 11 collective courses by gender in 2018/19



Mechanical Engineering student visits were removed from Figure 4.3 as the number of visits from this course grossly outnumbered the visits from the other courses. Their number of visits can be seen in Table 4.3. When comparing the proportions of students that engage in each course by comparing Figure 4.4, there is variability in engagement by gender with a higher proportion of males engaging on some courses and a higher proportion of females on others. The percentage difference in engagement between genders in Figure 4.4 highlights how major the gap is and how it differs by course. It also shows that there are very few visits made by psychologists. For Psychology, the University did not supply the demographic data for students on two course cohorts, but it is known that some of these students did engage with the centre. However, since there was no demographic data for these students, no students from these cohorts were included in the dataset.

Figure 4.4

Percentage of students that engaged with sigma from each course by gender in 2018/19



From Figure 4.4, it may seem as though in all courses, the percentage of students of both genders that engage with **sigma** is similar. However, when looking at the gender breakdown of the courses (Figure 4.3), there are very few female students in Motorsport Engineering, Automotive Engineering, and Aerospace Systems Engineering. Since there are so few female students in each of these groups, the effect of a single individual on the whole group can be quite large. This highlights the importance of gathering adequate sample sizes. More than just how female students are engaging with **sigma**, this further highlights how few females are successfully recruited onto these courses, which is a well-known problem for STEM subjects more generally.

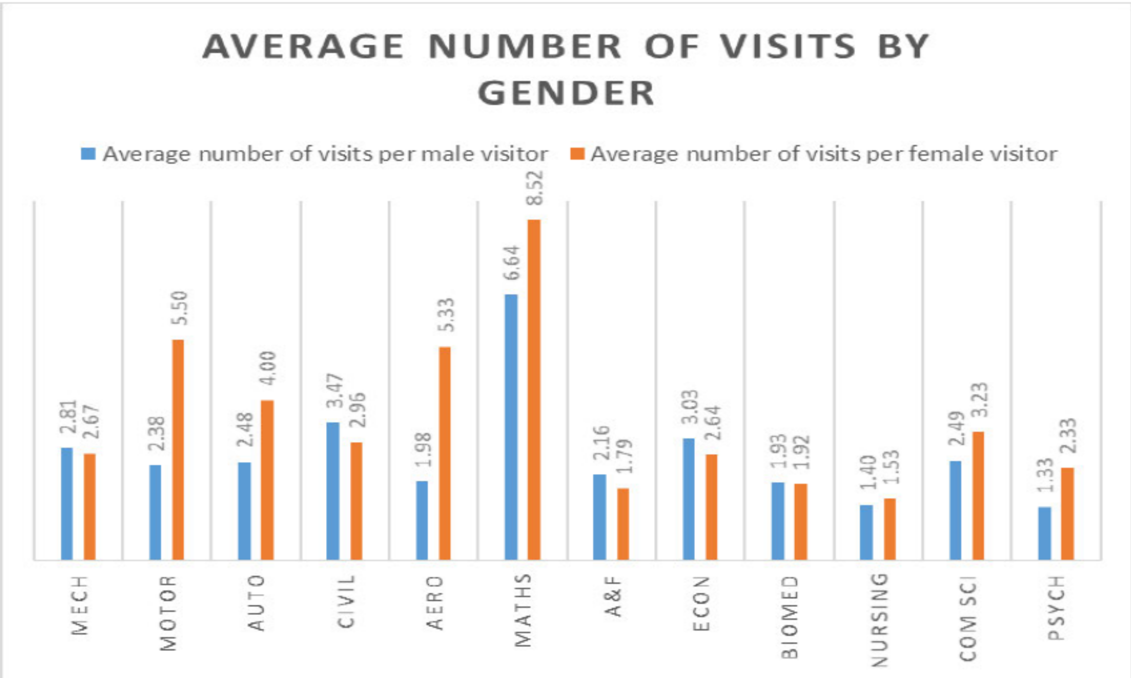
Mathematics was removed from Figure 4.4 as students from this course engaged noticeably more than students from other courses, with 81.97% of female students having engaged and 72.13% of male students. Staff who worked in **sigma** during 2018/19 recall that many mathematics students used the centre as a place to both work collaboratively and to interact socially with their peers. In the courses where the gender balance is closest, such as mathematics, Accounting and Finance, and biosciences, female student engage at a higher rate than male students.

4.2.5.1 Average number of visits

By finding the average number of visits, as seen in Figure 4.5, a clearer picture can be gathered of the return rates of both male and female students. From Table 4.1, it may seem as though male students are not only more likely to use the centre, but also to return. In actuality, it again depends on the course.

Figure 4.5

Average number of visits by gender in 2018/19



Most courses have both genders visiting at a similar level, though male students in Mechanical Engineering, Civil Engineering and Accounting and Finance engage more (but in each case by at most 0.5 of a visit). In Mathematics, Aerospace Systems Engineering, Motorsport Engineering and Automotive Engineering, female students attend much more (in each case by more than one visit).

This suggests that actually, a student's likelihood of returning does not depend on what the gender breakdown is in the course, but is perhaps more about intrinsic motivation (Saeed and Zyngier, 2012), which may increase as a student progresses through their chosen course, and other factors, such as their resilience.

Further investigation into why these students in particular choose to re-engage despite their peers choosing to only visit once may be interesting, but since the extent of return visits does not differ much by gender, instead it may be more appropriate to say that both male and female students, once they choose to visit **sigma**, do engage at a similar level.

4.2.6 Course stage

Table 4.4

Number of students, visitors and visits by course stage

Year	Students	Visitors	Visits	Percentage engaged	Average visits
1	2553	966	2708	37.84	2.80
2	2554	344	1185	13.47	3.44
3	1848	482	1127	26.08	2.34
4	92	11	25	11.96	2.27
Total	7047	1803	5045	25.59	2.80

Almost 40% of first-year students engaged with **sigma** in 2018/19, this was the highest proportion of any year group. The proportion engaging dropped to 13.5% in year 2 and then increased to 26.1% for year 3. This probably reflects that many students do not have a mathematics or statistics module in their second year but in the third year many of them do projects that involve statistics. The second-year students that did engage visited more often that students in other years. This may be because typically only those on mathematics-heavy courses have such content in their second year, and as established, the centre is often used as a social learning place for such students.

4.2.7 Ethnicity

Considering the awarding gap between white students and ethnically diverse students (Universities UK & NUS, 2019), measuring the relationship between ethnicity and student engagement with **sigma** was of considerable importance.

According to HESA (Higher Education Statistics Agency), ethnicity forms 11 categories. These were further collected to form seven groups, as seen in Table 4.5. This was to ensure a sufficient sample size of each group, as well as ease of comparison between datasets, since some University-held datasets had already been sorted to have only seven ethnicity groups.

Asian Pakistani and Asian Indian students were grouped together under the title "South Asian" and Black African and Black Other students were grouped together under the title "Black", again, to create appropriate sample sizes.

Table 4.5

Number of students, visitors and visits to sigma broken down by ethnicity

Ethnicity	Students	Visitors	Visits	Percentage engaged	Average visits
White	2662	617	1820	23.18	2.95
South Asian	1163	305	965	26.23	3.16
Chinese Asian	844	292	457	34.6	1.57
Asian Other	590	164	474	27.8	2.89
Black	1128	289	912	25.62	3.16
Mixed	194	30	76	15.46	2.53
Other Ethnicity	466	106	341	22.75	3.22
Total	7047	1803	5045	25.59	1.79

Students that did not declare their ethnicity were removed from the analysis. Chinese Asian students have the highest percentage of engagement with the centre by around seven percentage points, with mixed students having engaged the least, though it bears noting that mixed students form the smallest sample group. When considering average number of visits made by those who have already engaged, those categorised under having an "other ethnicity" have the highest rate of visits, slightly higher than Black and South Asian students.

Table 4.6

Number of students, visitors and visits to sigma by ethnicity

Ethnicity	Students	Visitors	Visits	Percentage engaged	Average visits
White	2662	617	1820	23.18	2.95
Ethnically diverse	4385	1186	3225	27.05	2.72
Total	7047	1803	5045	25.59	2.80

The above table collects all ethnicities other than white into a single group "Ethnically diverse". It can be seen that a higher percentage (almost four percentage points) of ethnically diverse students engage but that those white students who do engage have a slightly higher average number of visits.

4.2.8 Age

Another factor of interest is age. O'Sullivan et al. (2014) and Edwards and Carroll (2018) found mature students were more likely to engage with MSS, and so to identify whether this was also the case for **sigma**, number of visitors was measured against age of student. Due to the wide range of student ages, it was necessary to group students as being either mature (born before 1998) or non-mature (born either in or after 1998) since in 2018/19, this would mean students were between the "traditional" university age of 18-21. The breakdown of students by age by this grouping can be seen in the following table.

Table 4.7

Number of students, visitors, and visits to sigma by age

Age	Students	Visitors	Visits	Percentage engaged	Average visits
Mature	3220	996	2620	30.93	2.63
Non-Mature	3827	807	2425	21.09	3.00
Total	7047	1803	5045	25.59	2.80

A higher proportion of mature students use the drop-in centre, possibly because they require more help with the mathematical content on their courses after having been out of education (and perhaps not using mathematics much) for longer than "traditional" students. It may also be because they are more likely to make use of any support available. Mature students make up 46% of the dataset, and account for over 50% of the unique number of visitors and the total number of visits. A higher percentage of mature students have engaged with the centre, which raises the question as to why "traditional" students are using the support less. This is perhaps because mature students are more motivated to succeed on their course, possibly because they can see how mathematics is necessary for their career (Breen et al., 2015). However, there are many confounding factors here such as their form of study, caring or job responsibilities, which are hard to separate for mature students so drawing definitive conclusions is difficult. This highlights the importance of collecting and analysing qualitative data to really understand the data, which is addressed in Chapters 7 and 8.

4.2.9 Nationality

Table 4.8

*Number of students, visitors and visits to **sigma** by nationality*

Nationality	Students	Visitors	Visits	Percentage engaged	Average visits
Home	4889	1224	3748	25.04	3.06
International	2158	579	1297	26.83	2.24
Total	7047	1803	5045	25.59	2.80

25% of home students engaged with MSS in 2018/19, whilst 27% of international students did. Whilst international students engage slightly more, they visit less often once they have engaged; determining why they choose to not re-engage may be of interest. One such reason for some international students may be difficulties with communicating, which will be discussed further in Chapter 8.

4.2.10 Disability

sigma aims to be inclusive and ensure all students have an equal opportunity to access the services it provides. Therefore, to see if this aim was being met, disability was also analysed to see whether there was a relationship between this, engagement and repeat engagement. It must be noted that whilst **sigma** did not have an online drop-in centre in 2018, many resources for students could be found online, and provisions were made where possible for students who could not visit the centre. It is also worth noting that some students who do suffer from some form of mental or other disability may choose to not declare this to the university or may not have been officially diagnosed. This analysis has been carried out based on declared disabilities to the University, but **sigma** themselves do not ask students to disclose disabilities. Interestingly, in Newman et al. (2020, p.2), it was stated that “retention rates were higher for those who had accessed universally-available supports only, such as writing and math centers, which don’t require disclosure of a disability”.

For the analysis, students were grouped into either having a disability or not. The total number of students in each category can be found in Table 4.9.

Table 4.9

Number of students, visitors, and visits to sigma by disability status

Disability	Students	Visitors	Visits	Percentage engaged	Average visits
No	6525	1652	4559	25.32	2.76
Yes	522	151	486	28.93	3.22
Total	7047	1803	5045	25.59	2.80

Disabled students both engage slightly more with **sigma** and also have a higher number of visits, though the sample size for students with no disabilities is 12.5 times the size of those with a disability.

4.2.11 Statistical modelling

In Table 4.10, it can be seen that zero is inflated in the model since most students do not engage with **sigma** for various reasons.

Table 4.10

Number of visits made to sigma truncated at 15 visits

Number of visits	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Frequency	5244	929	344	138	101	57	51	30	29	18	19	13	16	11	8	9

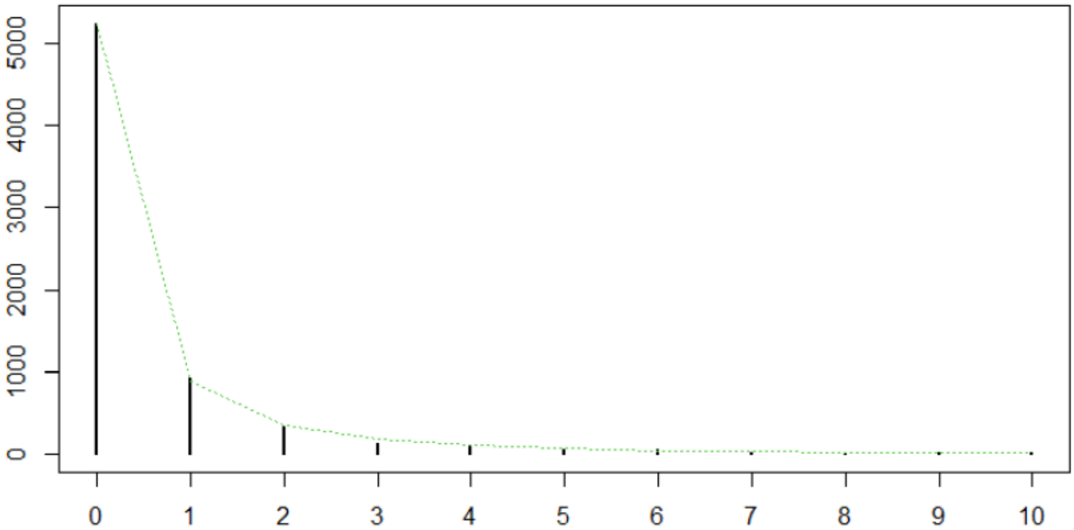
There are several models that can be used in such situations, one of which is a hurdle model (Ford, 2016). This two-part model was deemed to be particularly appropriate because of the way it takes into consideration the zero count data is by separating the data into two parts: the first part of the model deals with only the positive count data i.e., 1 visit or more and analyses differences in the numbers of visits made to **sigma**, whilst the second part of the model considers the zero count data as a binary variable i.e., whether a student visited (1) or not (0). It is when the "hurdle" is crossed that positive counts occur, and in this case, the hurdle is a student engaging with **sigma** at least once. In this way, not only could engagement with **sigma** be measured, but also repeat engagement, which has not yet been done in this manner, particularly regarding demographic engagement.

The first part of the model uses a Poisson or Negative Binomial distribution to process the positive counts, whilst the second uses binary logistic regression to process the zero count data.

A hurdle model was therefore fitted in "R" to identify which factors were predictors of engagement since it effectively models the zero count and positive count data separately. The factors tested were gender, course, ethnicity, age, nationality and disability. Course stage was not added to the model as it may have confounded the findings since course stage and age are related. To measure how well the model fit the set of observations, the goodness of fit was measured. The difference between the observed values and expected values can be seen in Figure 4.6.

Figure 4.6

Number of visits made to sigma truncated at 10 visits (vertical black lines) compared to predicted visits to sigma (green dotted line)



The predicted visits appeared to directly correspond to the actual visits made, which made the model an excellent fit. Since the model fits the data well, it was decided to proceed using a negative binomial model to process positive visits, whilst the binary logistic regression processed the zero-count data.

The first part of the model can be seen in the following table.

Table 4.11

Hurdle model for predicting rate of visits to mathematics support at Coventry University by different characteristics in 2018/19

Categories	β	e^{β}	p-value
Female	-.002	0.998	0.986
Ethnically diverse	0.154	1.166	0.150
Mathematics A level recommended	0.945	2.573	<.001
Mathematics A level required	1.237	3.445	<.001
Mature	-.229	0.795	.018
International	-.512	0.599	<.001
Disabled	.252	1.287	.158

The β value here represents the negative binomial regression coefficient, i.e., if there is a change in an independent (predictor) variable from the reference category to the one shown in Table 4.11 when all other variables are held constant, then β is the expected difference in the logs of the expected number of visits. This means that e^{β} returns the incidence rate ratio for each variable when the other variables in the model are held constant. For example, consider the row for female students. When other variables in the model are held constant, for female students, the expected log count of the number of visits decreases by .002 and so the expected average number of visits by female students is $e^{-0.002} = 0.998$ times that for male students. However, since the p value is 0.986, this (very small) difference is not significant. This means that once students had engaged, there was no significant difference in the number of visits made between males and females.

As seen in Table 4.5, Asian and black students engaged at a higher rate than white students. It was decided to amalgamate the various ethnicity groups into groups of white and ethnically diverse for the purpose of increasing statistical power, though again, it is worth reminding the reader that the engagement of the different ethnic groups did differ between one another. With white students used as the reference category, it was found that although ethnically diverse students engaged at a higher rate, this difference was not significant (p =.150).

For course type, no mathematics A level required was the baseline reference category. Both "A level Mathematics recommended" and "A level Mathematics required" had a higher rate of visits than those in the baseline category of no mathematics A level required, with p<.001 for both groups. For students on courses with a mathematics A level requirement, β=1.237 and $e^{\beta} = 3.445$ i.e., the incidence rate ratio (ie the ratio of {number of visits for A level required} to {number of visit for no maths requirement}) is 3.445. Therefore, students on courses with a mathematics A level requirement will visit on average 3.445 times as often as students on no maths requirement courses, which is significant.

Again, with age, students were categorised as mature or young. Mature students were significantly less likely to repeat visit, with their mean visits being $e^{0.229} = 0.795$, p = 0.018. On average, this meant mature students made 20.5% fewer visits.

When investigating nationality, it was found international students have a significantly lower visit rate than home students, p<.001, incidence rate ratio =$e^{-0.512} = 0.599$. In other words, the model predicts that international students will visit, on average, only 60% as many times as home students.

Disability was not a significant predictor of the number of visits students made (p =.158), which means the difference between the number of visits compared to students with no disability was not significant.

The second part of the model can be seen in the following table.

Table 4.12

Hurdle model for predicting engagement with mathematics support at Coventry University by different characteristics in 2018/19

Categories	β	e^{β}	p-value
Female	.256	1.292	<.001
Ethnically diverse	.340	1.405	<.001
Mathematics A level recommended	.597	1.817	<.001
Mathematics A level required	1.27	3.561	<.001
Mature	.503	1.654	<.001
International	.124	1.132	.047
Disabled	.215	1.240	.043

The second part of the model predicts whether students will engage with MSS or not. In this part of the model, e^{β} in this model is an adjusted odds ratio, not an incidence rate ratio. It is adjusted to account for the other predictor variables considered in the model, so this value shows how predictor variables affect the odds of a visit to **sigma** happening after the other variables have been controlled for.

In this part of the model, it was found that gender did significantly predict whether a student would visit **sigma**, $e^{0.256} = 1.292$, p<.001. This means the odds of female students visiting **sigma** at all were 1.29 times those for male students. Gender is a statistically significant predictor when considering engagement with **sigma**.

The second part of the hurdle model showed that both students from courses where A level Mathematics is recommended (adjusted odds ratio is 1.817, p<.001) and courses where an A level in mathematics is required (adjusted odds ratio was 3.561, p<.001) were both significantly more likely to engage than students with no A level Mathematics requirement.

After adjusting for the other factors in the model, ethnicity has a significant impact on engagement with **sigma** (p<0.001). Compared to white students, ethnically diverse students were significantly more likely to use MSS at least once by around 1.4 times ($e^{\beta} = 1.405$, p<.001).

Age was found to be a significant predictor of engagement, with mature students visiting **sigma** at least once around 1.6 times more often than non-mature students.

International students were significantly more likely to visit **sigma** than home students, with an odds ratio of 1.132, p=.047.

Students with disabilities are significantly more likely to engage with **sigma**, with an adjusted odds ratio of $e^{0.215} = 1.240$, p=.043**.** This means that, after adjusting for the other terms in the model, the odds that a disabled student will engage with **sigma** are 1.24 times the odds that a non-disabled student will engage. This provides some evidence that **sigma** has succeeded in its aim to create an inclusive environment, though the collection of qualitative data would be needed to reinforce this finding.

Rather than presenting a model which still contains things that had no significant effect, it is generally recommended to remove the non-significant variables one by one and continually check the fit of the model, with the general assumption that removing non-significant variables will improve the fit of the model. The idea is that this then shows the importance of the predictors. Since gender, ethnicity and disability were non-significant, they were removed only from the first part of the model and log-likelihood scores were compared. Log-likelihood values are used to compare the fit of a model, with a higher log-likelihood value indicating that that model fits the dataset better. The log-likelihood value of the model in Table 4.11 and 4.12 had the highest value, and therefore, the model is presented with all non-significant factors since this model fit the dataset best.

Attendance data from the 2020/21 academic year will now be discussed.

4.3 Attendance data from 2020/21

4.3.1 Sample

Data from the academic year of 2020/21 was also analysed to gain insight into how the pandemic affected engagement with **sigma** since support at this point was primarily online due to mandated government lockdowns. 2155 visits were made by 799 visitors, which is a considerable decrease from the previous year. The interruption of regular support and studies due to the pandemic is most likely the reason for this decrease, with many institutions reporting fewer visits to MSS (Gilbert et al, 2021). Again, University data was obtained on student demographic characteristics and course details to create a better understanding of engagement across the same collective courses that were analysed as in the previous dataset. The spread of visits looked vastly different. Whilst students from mathematics and engineering courses previously provided the most visits to MSS, students from Health and Life Science courses (such as the biosciences and nursing) overtook them, accounting for 48% of the visits compared with only 28% by engineering, mathematics and computing courses.

Outliers were not removed from the dataset since the maximum number of visits made in 2020/21 was 18. This was the cut-off point for outliers in the 2018/19 dataset, so to be consistent with this value no students were removed in 2020/21. It was surmised that students with more than 18 repeat visits in 2018/19 were most likely using the centre as a social learning space and this was not possible in 2020/21. It was therefore deemed reasonable not to treat any values in 2020/21 as outlier values that should be removed from the analysis.

In the sections that follow, rather than considering every course, we consider visits by students from the same 12 collective course groupings as were used in the analysis of 2018/19 data in Section 4.1.

4.3.2 Gender

As in 2018/19, approximately 40% of students in the dataset are female, as seen in Table 4.13.

Table 4.13

Total number of students in the dataset, percentage of engagement, and average number of visits made to sigma per student, broken down by gender

Variable	Total	Male	Female
Number of students	5967	3527	2440
Number of unique visitors	524	191	333
Total number of visits	1476	506	970
% of students who visit at least once	8.78	5.42	13.65
Average number of visits per student	2.82	2.65	2.91

It is clear that there was a considerable decrease in engagement from 2018/19 to 2020/21, from 26.07% of students visiting to 8.8%. When dividing this by gender, male engagement dropped from 28% to 5.42%, and female engagement from 23.02% to 13.69%. However, when looking at the average number of visits per student, their level of engagement did not change much from 2018/19 to 2020/21; for male students, it dropped from 2.87 to 2.59, whilst average visits from female students actually increased from 2.50 to 2.94. Furthermore, 64% of visitors were female in 2020/21 compared to only 34% in 2018/19 and females also visited the centre more often than male students in 2020/21. This is at odds with what is seen for the 2018/19 academic year, which showed male students availed of the support more. Although engagement with MSS decreased in 2020/21, it appears that those students who did engage did so at a similar rate to those who engaged in 2018/19. This suggests that the students who did engage found online support satisfactory as a medium of providing help, particularly for female students. This may be related to female students typically being more MA than male students (Johnston-Wilder et al., 2014; Devine et al., 2012) (see Chapter 5).

4.3.3 Course

Student engagement by course is now detailed.

Table 4.14

Number of students, visitors and visits made to sigma by different courses

Courses	Total	Visitors	Visits	Percentage engaged	Average visits
Mechanical Engineering	852	47	142	5.52	3.02
Motorsport Engineering	157	2	4	1.27	2.00
Automotive Engineering	240	8	23	3.33	2.88
Civil Engineering	565	19	56	3.36	2.95
Aerospace Systems Engineering	138	17	31	12.32	1.82
Mathematics	144	32	111	22.22	3.47
Accounting and Finance	626	56	175	8.95	3.13
Economics	340	17	51	5.00	3.00
Biomedical Science	867	109	303	12.57	2.78
Adult Nursing	433	65	164	15.01	2.52
Computer Science	689	41	102	5.95	2.49
Psychology	916	111	314	12.12	2.83

As seen in Table 4.13, the proportion of female visitors in 2020/21 was much higher than in 2018/19. This may be because there are more female students in courses with some level of statistics, creating the difference since mathematics is more difficult to assist with online (Mullen et al., 2021). This change in engagement also could be explained by the anonymity that the online support brings (Hodds, 2021), potentially making female students from Health and Life Sciences (HLS) courses more comfortable with engaging since they are not in a physical space that may be dominated by "mathematicians". Increased visibility of MSS on these courses during the 2020/21 academic year may also explain this.

What must first be noted is the relatively small class size of mathematics and motorsport engineering compared to the other cohorts. The proportion of mathematics students who availed of the centre was the highest. Compared to the high level of engagement seen from engineering students in 2018/19, there is a remarkable drop in engagement. However, it is also evident that there has been an increase in engagement from students on courses that did not traditionally engage with MSS as often as Engineering, Environment and Computing (EEC) students, typically those from HLS courses. When mathematics students are not considered, Adult Nursing (15.01%) and Biomedical Science (12.57%) had the highest proportions of students engaging with the online centre, whereas in 2018/19, only 7.28% of bioscience students had engaged, so this increase is particularly noteworthy.

4.3.4 Course and gender

To compare the engagement by gender on each collective course group, this information has been shared in the following graphs.

Figure 4.7

Number of students in all 12 collective courses by gender in 2020/21

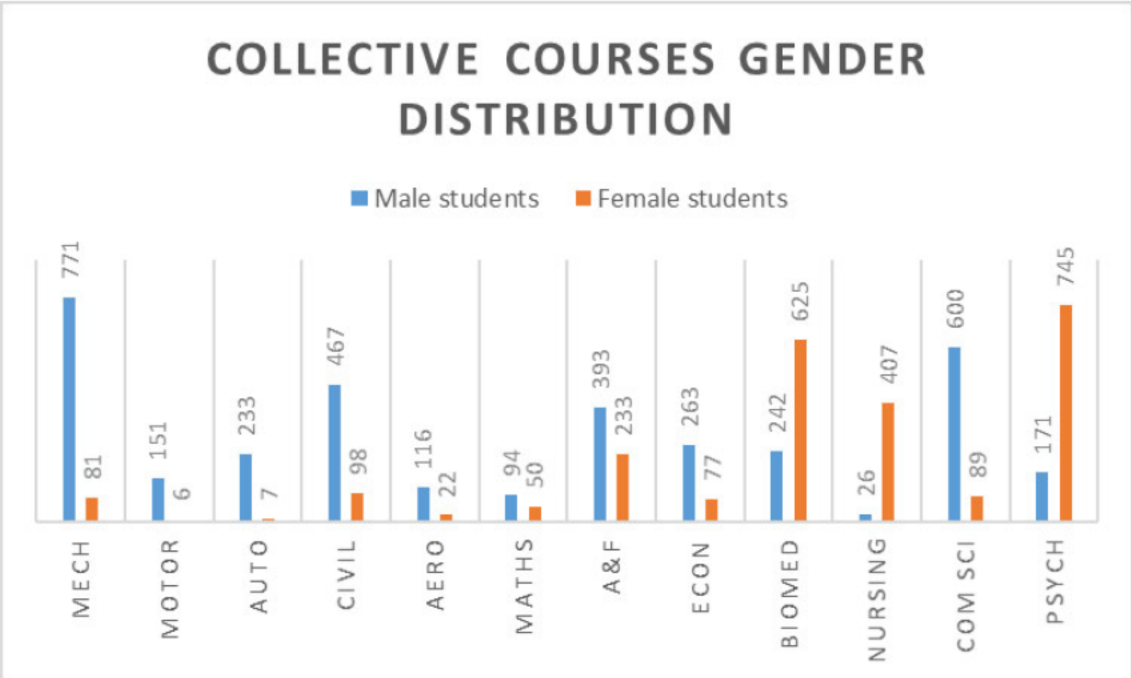
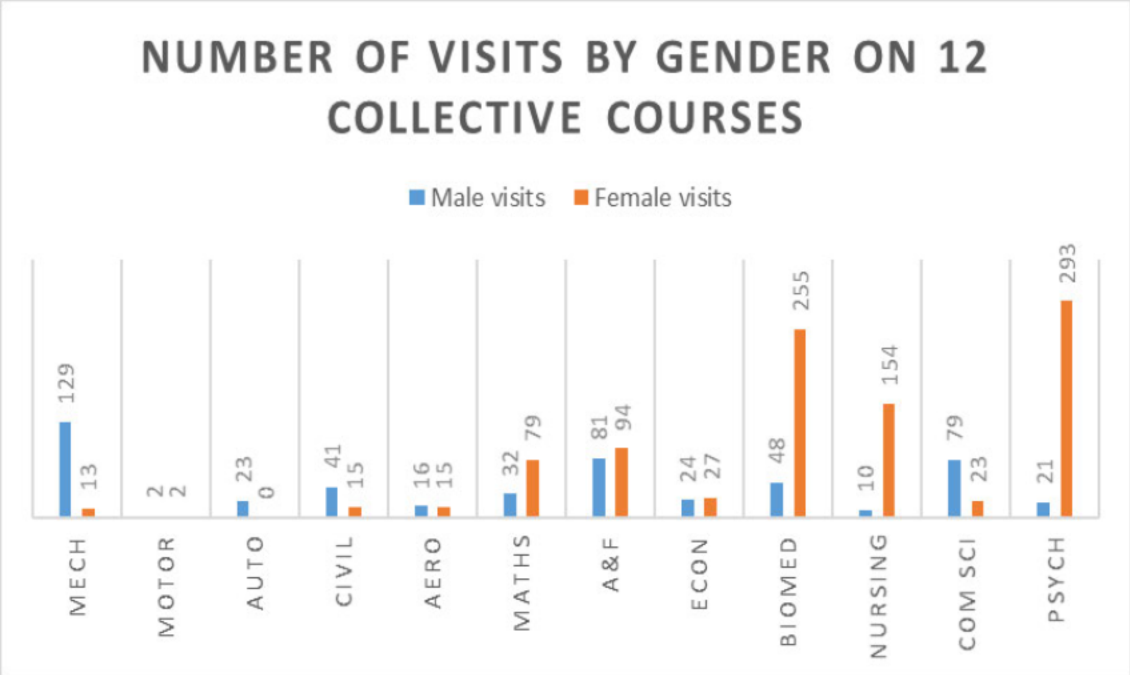


Figure 4.8

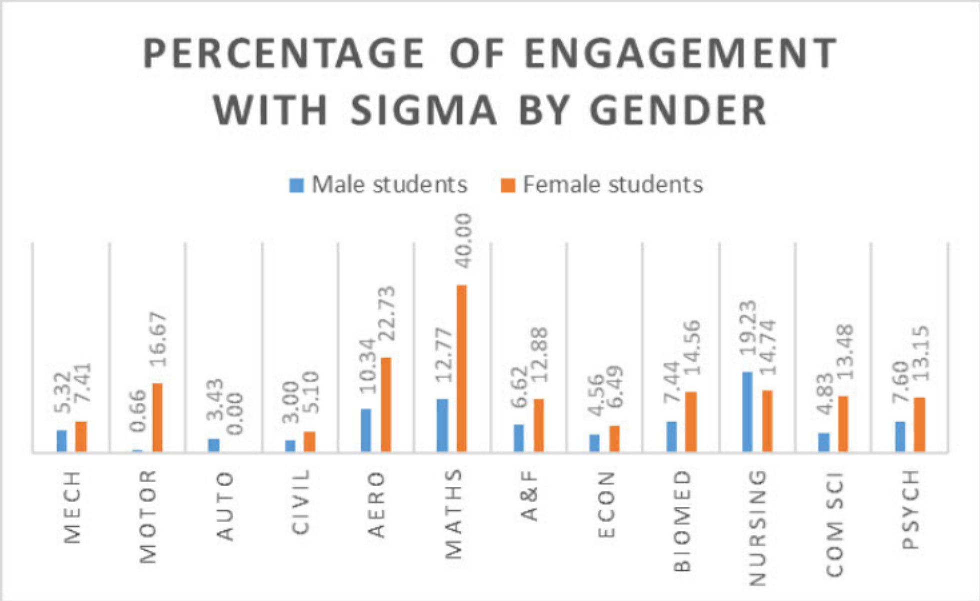
Number of visits to sigma by students from 12 collective courses by gender in 2020/21



As expected, the engagement by genders differs according to the number of students enrolled on the course. For female-dominated courses such as biosciences and Psychology, visits from female students vastly outweighs the visits made my male students. The opposite trend is seen for courses such as engineering. However, mathematics, being the course with the most equal breakdown of students by gender, female students again engage at a much higher rate.

Figure 4.9

Percentage of students that engaged with sigma from each course by gender in 2020/21



Overall, female mathematics students and female Aerospace Engineering students have the highest percentage of enrolled students engaging with **sigma**. This is closely followed by male Adult Nursing and female motorsport engineering students. Small numbers of enrolled students on courses by gender can greatly impact the gender percentage engagement of courses, so these findings must be accepted cautiously.

To understand how entry course requirements may affect engagement with MSS, courses have again been amalgamated according to the entry grades required for these select courses.

Table 4.15

Number of students, visitors and visits made to sigma by different course groups in 2020/21

Course Type	Students	Visitors	Visits	% engaged	Average visits
No mathematics A level requirement	3532	382	1069	10.82	2.80
Mathematics A level recommended	905	36	98	3.98	2.72
Mathematics A level required	1530	106	309	6.93	2.92
Total	5967	524	1476	8.78	2.82

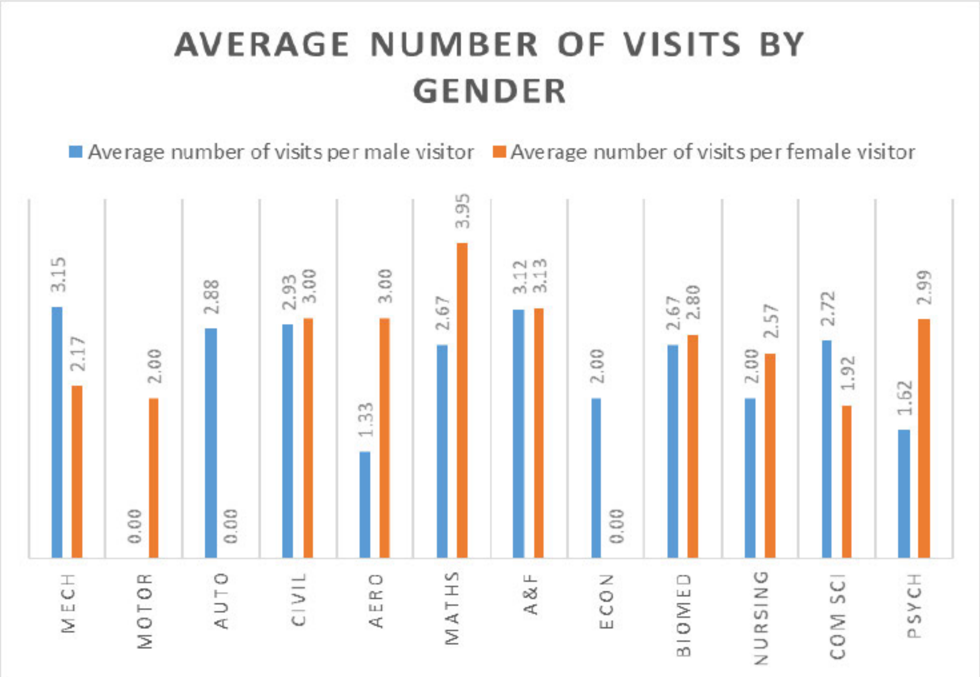
Again, there is a significant shift away from the supposed "traditional" engagement **sigma** usually sees to courses with no A level requirement. Though there is a drop in engagement by around a third for courses with no mathematics requirement, this course type had the highest level of engagement, which may partially be explained by the work conducted by **sigma** staff to advertise to these cohorts and encourage their engagement through interventions. Furthermore, it is harder to deliver support for students on highly mathematical courses online due to the complicated syntax that is generally used.

4.3.5 Average visits

As before, the average number of visits by gender and by course has been shared in the following graphs.

Figure 4.10

Average number of visits by gender in 2020/21



It is evident that there is a significant decrease in return visits from specific courses, particularly from engineering and mathematics courses, again, which may be explained by the difficulty involved with supporting these students on an online platform. Return visits from female mathematics students is the most common, which was also the case in 2018/19. However, where in 2018/19 some of these return visits may have been due to students using the centre as a social space, this cannot be the case for the 2020/21 academic year. Repeat visits from female mathematicians dropped from 8.52 to 4.15. The only courses that showed an increase in repeat visits for both male and female students were the Biosciences, Adult Nursing and Psychology. However, as mentioned earlier, overall, the repeat engagement from students in 2020/21 and 2018/19 was similar.

4.3.6 Ethnicity

The same ethnicity groupings used in the 2018/19 analysis were used for this subsequent analysis.

Table 4.16

Number of students, visitors, visits, and percentage of engagement of students by ethnicity

Ethnicity	Students	Visitors	Visits	% engaged	Average visits
White	2216	180	517	8.12	2.87
South Asian	1151	100	280	8.69	2.80
Chinese Asian	384	16	50	4.17	3.13
Asian Other	542	39	116	7.20	2.97
Black	1050	129	331	12.29	2.57
Mixed	205	21	50	10.24	2.38
Other Ethnicity	380	35	121	9.21	3.46
Unknown	39	4	11	10.26	2.75
Total	5967	524	1476	8.78	2.82

Black students engaged more than any other ethnicity group, with Chinese Asian students engaging the least. Students categorised as "Other ethnicity" visited more often than the other ethnicity groups, with mixed students having the lowest average number of visits.

Table 4.17

Number of students, visitors, visits, and percentage of engagement of students by grouped ethnicity

Ethnicity	Students	Visitors	Visits	Average visits	Percentage engaged
White	2216	180	517	2.87	8.22
Non-white	3712	340	948	2.78	9.16
Total	5928	520	1465	2.82	8.81

When ethnically diverse students were grouped together as non-white for the purpose of the analysis (omitting the 39 students with unknown ethnicity), it was found ethnically diverse students had engaged slightly more than white students during the pandemic.

4.3.7 Age

Of all the demographic characteristics considered, there was perhaps the largest disparity in engagement between the two age groups: mature and non-mature.

Table 4.18

Number of students, visitors, visits, and percentage of engagement of students by age

Age	Students	Visitors	Visits	Percentage engaged	Average visits
Mature	3226	365	1037	11.31	2.84
Non-Mature	2741	159	439	5.8	2.76
Total	5967	524	1476	8.78	2.82

Mature students were almost twice as likely to have engaged with the centre and also had a higher rate of visits, as opposed to 2018/19, when non-mature students had a higher rate.

4.3.8 Nationality

Table 4.19

Number of students, visitors, visits, and percentage of engagement of students by nationality

Nationality	Students	Visitors	Visits	Percentage engaged	Average visits
Home	4841	371	1124	7.66	3.03
International	1124	151	344	13.43	2.28
Total	5965	522	1468	8.75	2.81

Despite there being fewer international students in 2020 due to COVID restrictions, international students were still more engaged with the support, but the average number of visits made by each group stayed approximately the same. Data for the nationality of two students was missing.

4.3.9 Course stage

Table 4.20

Number of students, visitors, visits, and percentage of engagement of students by course stage

Year	Students	Visitors	Visits	Percentage engaged	Average visits
1	1370	130	310	9.49	2.38
2	2062	79	222	3.83	2.81
3	2346	211	694	8.99	3.29
4	97	12	30	12.37	2.50
Masters	92	92	220	100	2.39
Total	5967	524	1476	8.78	2.82

100% of Masters students in the dataset engaged with **sigma**, though both fourth-year and Masters students made up only 2% of the whole dataset.

Most visits came from students in their later years, most likely those on courses with project requirements that involved the use of statistics, such as Psychology. If fourth-year engagement is disregarded due to the small sample size, first-year students had the highest percentage of students engaging, though this is only 9.56%, a drastic decrease from the 2018/19 academic year.

4.3.10 Disability

Table 4.21

Number of students, visitors, visits, and percentage of engagement of students by disability

Disability	Students	Visitors	Visits	Percentage engaged	Average visits
No	5424	453	1269	8.35	2.8
Yes	536	67	193	12.5	2.88
Total	5960	520	1462	8.72	2.81

Students with disabilities had both a higher rate of visits to the centre and a higher percentage of students had engaged too. The assumption was not made that those who did not declare a disability had no disability; as such, there is some student data missing from the table.

4.3.11 Model

Again, due to the inflation of zero count data, as can be seen in the following table, a hurdle model was used to both assess the factors affecting whether a student chose to engage or not, as well as their rate of visits once they had engaged.

Table 4.22

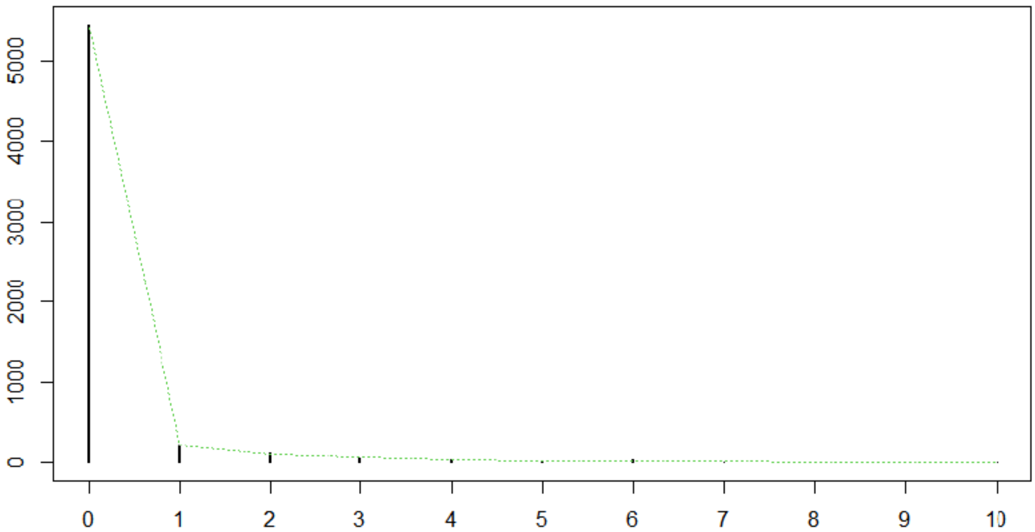
Frequency of visits made to sigma truncated at 17 visits

Visits	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	17
Frequency	5453	209	115	59	36	26	28	6	8	5	5	4	4	1	1	3	1

The same factors included in the 2018/19 hurdle model were investigated here. A negative binomial model was used to fit the positive counts and a binary logistic regression for the zero-count data as before. The goodness of fit can be seen in the following graph.

Figure 4.11

Number of visits made to sigma truncated at 10 visits (vertical black lines) compared to predicted visits to sigma (green dotted line)



Non-significant variables were removed in turn with log-likelihoods of each model compared to determine which model was the best fit. The model with all non-significant variables still included had the highest log-likelihood value and thus, this is reported below, with part one of the model predicting the rate of visits.

Table 4.23

Hurdle model for predicting rate of visits with mathematics support at Coventry University by different characteristics in 2020/21

Categories	B	e^{β}	p-value
Female	.051	1.052	0.438
Ethnically diverse	.012	1.012	0.864
Mathematics A level recommended	0.126	1.134	.506
Mathematics A level required	0.016	1.016	.958
Mature	0.064	1.066	.693
International	-.497	.608	.003
Disabled	.010	1.01	.965

As in 2018/19, neither gender nor ethnicity significantly predicted rate of visits, meaning once a student had engaged, neither factor impacted the likelihood of them repeat visiting when all other factors were controlled. Unlike in 2018/19, age and course type also were not significant predictors of rate of visits. Although course type still showed the same trend as in 2018/19, with those on courses with no mathematics A level requirement having the lowest rate of visits, it was clear to see that there had been a marked increase in the repeat visits, considering the difference was no longer significant. The rate of visits for mature students switched in 2020/21, with them now repeat visiting more than non-mature students, though this difference was very slight and non-significant. The same was found with disability, with the difference in rate of visits being almost negligible. The only factor that was returned as significant in the first part of the hurdle model was nationality, with international students repeat visiting significantly less than home students. With the nature of the pandemic, this is perhaps not surprising especially when also considering that for online support to be a practical alternative to face-to-face support, a stable internet connection alone is the basic requirement, and some students would be studying from countries with potentially limited or poor internet access.

Table 4.24

Hurdle model for predicting engagement with mathematics support at Coventry University by different characteristics in 2020/21

Categories	B	e^{β}	p-value
Female	1.04	2.892	<.001
Ethnically diverse	-.041	.960	.701
Mathematics A level recommended	-.098	.907	.463
Mathematics A level required	-.737	.479	<.001
Mature	.698	2.01	<.001
International	.730	2.075	<.001
Disabled	.367	1.443	.014

In the second part of the hurdle model, ethnicity was found to be a non-significant predictor of engagement with p=.701, meaning both white and ethnically diverse students engaged at least once with the centre at a similar level. Course type was only found to be a significant predictor for a mathematics A-level prerequisite. However, it bears noting here that in 2020/21, ethnically diverse students did engage very slightly less than white students, though the opposite was seen in 2018/19. With course type, the difference in engagement between students on courses with no mathematics A level prerequisite and those on courses with a requirement was statistically significant, with those on courses with a requirement returning $e^{\beta} = 0.479$, p<.001. This is a drastic change from what was seen in 2018/19, with the results showing that students on courses with traditionally low engagement with **sigma**, such as the Biosciences, showing a significantly higher level of engagement with MSS than those on engineering and mathematics courses.

4.4 Discussion

To ease the comparison of the different demographic characteristics across both academic years, the findings have been repeated in Table 4.25 and 4.26, with the 2018/19 results in the second, third and fourth column of the tables.

Table 4.25

Hurdle model for predicting engagement with mathematics support at Coventry University by different characteristics

	2018/19			2020/21		
Categories	**β**	e^{β}	**p-value**	**β**	e^{β}	**p-value**
Female	.256	1.292	<.001	1.04	2.892	<.001
Ethnically diverse	.340	1.405	<.001	-.041	.960	.701
Mathematics A level recommended	.597	1.817	<.001	-.098	.907	.463
Mathematics A level required	1.27	3.561	<.001	-.737	.479	<.001
Mature	.503	1.654	<.001	.698	2.01	<.001
International	.124	1.132	.047	.730	2.075	<.001
Disabled	.215	1.240	.043	.367	1.443	.014

Table 4.26

Hurdle model for predicting rate of visits with mathematics support at Coventry University by different characteristics

	2018/19			2020/21		
Categories	**B**	e^{β}	**p-value**	**β**	e^{β}	**p-value**
Female	-.002	0.998	0.986	.051	1.052	0.438
Ethnically diverse	0.154	1.166	0.150	.012	1.012	0.864
Mathematics A level recommended	0.945	2.573	<.001	0.126	1.134	.506
Mathematics A level required	1.237	3.445	<.001	0.016	1.016	.958
Mature	-.229	0.795	.018	0.064	1.066	.693
International	-.512	0.599	<.001	-.497	.608	.003
Disabled	.252	1.287	.158	.010	1.01	.965

The aim of this chapter was to determine the effect of specific and combined demographic factors on engagement with MSS in the academic years of 2018/19 and 2020/21. Secondary quantitative data was used to answer these questions from CU's data on student demographics and **sigma** attendance data for student visits. The data was analysed through a variety of statistical analyses, revealing which demographic characteristics appeared to have a significant effect on student engagement with MSS.

These results differed widely by course, as seen in the hurdle model for 2018/19 in Table 4.11 and 4.12, where course type (depending on the A level Mathematics or equivalent requirement) returned a p-value of <.001 for both rate of visits and engagement. This may be unsurprising since those that on mathematics-heavy courses have more mathematics/statistics related content on their course and thus, these students engage more with the support.

When a subset of the 2018/19 data was analysed in Gokhool et al. (2021) to investigate the demographic engagement of only engineering students, it was found that those who were demographically underrepresented in engineering were more likely to engage. This was evidently also the case when the entire dataset was analysed herein, which also included health and life science courses. However, some local factors may also be having an influence. Student proctors tend to study mathematics or engineering courses, which may attract students from these courses due to a role model effect (Grove et al., 2020b) or due to the proctors promoting the centre to their friends and peers. Further to this, one of the tutors in the centre in the 2018/19 academic year was a retired Mechanical Engineering lecturer that students may have recognised. Considering Mechanical Engineering provided one of the highest numbers of visits to the centre in this year, this may be one such local explanation. In 2020/21, where support was provided online and there were no proctors, visits from students on mathematics and engineering courses dropped significantly providing some evidence for this.

Students from mathematics in particular have a high rate of engagement with **sigma,** though these students were known in 2018/19 to use the space for social learning. This suggests that **sigma** has been successful in its aim of creating an open, inviting space. However, there is a danger that these students may monopolise the space and make those from non-mathematics backgrounds, who may perhaps need more motivation to seek mathematics support, feel more reserved about engaging with **sigma**. Creating a separate space just for the mathematics students has been attempted before and was unsuccessful, so other interventions must be looked at to keep engagement with **sigma** high from students of all disciplines without ostracising mathematicians (Solomon et al., 2010; MacGillivray, 2009).

In “normal times”, many visits to **sigma** are encouraged by students being able to see and visit the centre for themselves, since it is in a prominent and visible section of the University library. This was, of course, not possible due to the pandemic, with the pandemic itself providing its own set of challenges and concerns for students outside of their studies. This was mirrored in many institutions (Gilbert et al., 2021). Although efforts were made to advertise the online drop-in service in other ways, there was still a large decrease in engagement. This decline in number of visits highlighted some interesting changes in the demographic engagement of students with MSS.

As aforementioned, it is engineering and mathematics students that typically dominate the centre when considering both visits and visitors. However, as can be seen in Table 4.15, students on courses with no mathematics A level requirement actually engaged more in 2020/21 (10.82%) than students on courses with an A level Mathematics requirement (6.93%) when the services were all online. The danger of the space being monopolised by mathematicians using the centre as a social learning space and thereby causing others to be inhibited from engaging because of this went away since there was no longer a social learning space. This may partly explain the relative rise in engagement of students from disciplines that are not mathematics-heavy.

The odds of female students engaging were 1.29 times higher than the odds of male students engaging, mirroring Ní Fhloinn et al.’s findings (2016), which claimed that female students were significantly more likely to engage due to a potential lack of confidence in their mathematical skills, which may also be the case for the students in this dataset. However, when looking at the rate of student visits, amongst those who did engage, by gender, there was no marked difference in the number of visits made to the centre. This work is the first known work conducted on student rate of visit, and thus, these findings cannot yet be supported by other literature. In 2020/21, this was again the case with female students significantly more likely to engage (and in this year, 2.9 times more likely than males), though again gender was not a factor for predicting repeat engagement.

Whilst home students were less likely to initially avail of the service, once they had successfully engaged, they visited at a higher rate than international students in both academic years investigated. The prior qualifications of international students can be quite different to that of home students, with some being more rigorous and others being less so. The difference in fees as well as potential cultural and familial pressures to perform well may encourage these students to use the available support as often as needed. This may particularly be the case once students realise that are likely to achieve better grades in their course by engaging, because the stakes are perhaps viewed as higher for them. This does not necessarily just include MSS support. As such, international students may be more likely to ask for support from lecturers, from peers or family members. However, whilst they engaged more, language barriers may make it more difficult for international students to use MSS since mathematics and statistics are already notoriously different to communicate to others compared to other subjects (Mullen et al., 2021), hence the lower rate of visits.

Age was another especially interesting factor. In 2018/19, mature students were shown to engage significantly more than non-mature students, with $e^{\beta} = 1.6$, p<.001. However, when looking at visits as a scale variable, the results showed the opposite effect, with non-mature students having a higher rate of visits. The first of these findings is supported by research from Edwards and Carroll (2018), Fitzmaurice et al. (2016) and Dzator and Dzator (2020) who confirm that mature students are more likely to engage. However, there is no separate analysis done on both the likelihood of a single visit and the rate of visits. Therefore, there is no current explanation in the literature as to why non-mature students visited the centre more often than mature students in 2018/19. Visits to the centre steadily increase around coursework deadlines and exam times, although this may not be the case for mature students, who, typically, are more driven by intrinsic rather than extrinsic motivation (McCune, 2010). Whilst traditional students may visit very often around their exam time to get the specialised help they need because they are perhaps more driven by a fear of failure, mature students may visit only when specific help is needed. They are also perhaps less likely to be driven away from seeking support from lecturers due to embarrassment since there is a higher need to succeed on their course and thus, they are more motivated (Breen et al., 2015) and have a desire to understand the material (Breen et al., 2015). This may not be the case for non-mature students, who use MSS sometimes as an alternative to lecturer help (see Chapter 8). The same hurdle analysis in 2020/21 found that whilst age did not significantly affect rate of visits, mature students did engage more (they were over twice as likely to engage).

Although ethnically diverse students were grouped together for the hurdle model analysis, some interesting results were still discovered. The data suggested that the odds of ethnically diverse students engaging were 1.4 times higher than the odds of white students engaging with the centre in 2018/19 after controlling for all other factors in the model, whilst in 2020/21, there was no significant difference. This provides some evidence away from the deficit model and supports what was stated in Panesar (2014) that using institutional data is key to fighting assumptions about the engagement of ethnically diverse students and its apparent association to the ethnicity awarding gap. Indeed, Panesar (2014) also found that ethnically diverse students were more likely to engage with academic support. Cultural factors may be at play here; for those cultures that place high levels of importance on mathematics, there may still be differences in how this is viewed. Some may believe that mathematical ability should be grown through any means necessary, such as engagement with MSS, whilst others may view engagement with such support as a sign of weakness. Another factor that may influence engagement may be the sense of belonging students have at the institution. In the academic year of 2018/19, three **sigma** staff members were of Asian descent. This highlights the paramount importance of promoting diversity as well as skill in staff roles as students seeing visible "role models" could encourage engagement. Another positive finding is that when comparing the number of repeat visits made to the centre (both in 2018/19 and 2020/21), there was not a significant difference in the rate of visits by ethnicity, perhaps showing that once students engage, they are likely to feel as comfortable as the other groups in engaging again. Further work on the relationship between engagement with MSS and ethnicity would be of interest, particularly to determine what influences the engagement of the different ethnic groups, though the findings from this data do suggest that other interventions may be more beneficial than one that targets ethnically diverse students.

Students with declared disabilities were found to not only significantly engage more than students with no disabilities in both academic years (around 1.3 times more), but they also engaged at a higher rate (though this was not significant), indicating that the initiatives undertaken by **sigma** to support disabled students had some success. It may also be because students with disabilities are accustomed to seeking support with their studies more generally, and thus seek support from MSS when needed. They are also perhaps more likely to be guided to the support available by university staff. Cliffe et al. (2020) is a noted piece of work on staff awareness of disabilities, stating the need for training staff regarding disability awareness and creating resources that accommodate to students with disabilities, which is work that is already being carried out in the field of MSS. These all indicate the need to continue improving access to MSS services for these students, and all students who may benefit from the additional support MSS can provide.

To summarise, in 2018/19, all considered demographic factors were significant predictors of whether or not students engaged with MSS, but in 2020/21, ethnicity was found not to be a significant predictor, indicating that behaviour across the two years was broadly the same. However, further investigation found this was not the case. In both years, female students were more likely to engage, but the odds ratio increased from 1.3 to 2.9. For course type, the reference category is no mathematics A level requirement. In 2018/19, students on courses where an A level in mathematics was required had an odds ratio 1.8 times higher than that of the reference category, but in 2020/21 it was only 0.48 times, i.e., the category with the highest odds of engaging switched from A level required to no A level requirement. The changes related to mature and disabled characteristics were much smaller. However, for nationality, the odds ratio almost doubled from 1.1 to 2.08 (with the odds of international students engaging being greater).

In terms of repeat engagement, nationality, course type and age significantly predicted rate of visits in 2018/19, but only nationality was a predictor in 2020/21, perhaps due to the confounding effect of the pandemic. However, this may imply that it is overcoming the hurdle of availing of the support that is difficult for certain groups of students; once students actually do engage, their experience of the support provided to them and the value they place on it (measured as a proxy by number of return visits) is not significantly influenced by the different characteristics investigated in this study.

4.5 Summary

The academic years of 2018/19 and 2020/21 were chosen to be investigated further to determine the impact of student characteristics on engagement and repeat engagement. University data was used to provide context to **sigma** attendance data, with findings around the total percentage of engagement and the average number of visits made by different demographic groups produced. Engagement was looked at from two different perspectives: single-level engagement and repeated engagement.

A hurdle model was used to investigate the difference in level of engagement with **sigma** (i.e., of students who have chosen to engage or not) and engagement overall (i.e., total number of visits made by a student). This model was chosen since it accounts for an excess of zero counts, which is the case for this dataset, since most students do not engage with **sigma**.

There is a difference in the predictors of engagement and repeat engagement. In the first instance, in 2018/19, all investigated factors predicted engagement, with female, ethnically diverse, mature, international, disabled students and those on courses with an A level Mathematics requirement more likely to engage. When considering repeat engagement, course type, age, and nationality were predictors, with non-mature, home and those on mathematics-heavy courses engaging more often. There is some strong evidence provided here that ethnically diverse students do not engage less than white students with MSS services, in agreement with other research about engagement with academic services more generally (Panesar, 2017).

It is evident that a substantial decrease in student engagement occurred in the academic year of 2020/21 due to the pandemic and the sudden shift to online support. There was also some notable change in the demographic characteristics of those that engaged. For the 2020/21 academic year, gender, age, nationality, disability and course type were significant predictors of engagement exactly as in 2018/19. Furthermore, in some cases, there was a more pronounced difference when considering the odds ratios, such as in gender, where the odds of engagement for female students increased from 1.3x to 3x that of the odds of the engagement of male students from 2018/19 to 2020/21. However, the course type that engaged the most switched to those from courses with no mathematics A level prerequisite. Ethnicity was not a significant predictor of engagement, unlike in 2018/19. With regard to repeat engagement, only nationality was a significant predictor in 2020/21, with home students visiting more often. This reduction in the number of significant predictors for repeat engagement is potentially due to the disturbance that occurred this year to the pandemic. The key points from this analysis are summarised below:

- Students in 2018/19 engaged far more than those in 2020/21.
- When considering repeat visits to **sigma** in 2020/21, it was at a similar level to that in 2018/19, indicating that once students overcame the initial hurdle of seeking online support, their repeat engagement did not differ. This can also be seen from the hurdle model analysis.
- Female students visited **sigma** more often in 2020/21 than male students, whereas in 2018/19, male students engaged more often.
- In terms of engagement or not, in 2018/19, being female, ethnically diverse, mature, a home student, on courses with a mathematics A level requirement, and having a disability, when controlling for each respective factor, predicted higher engagement.
- There was no significant difference in engagement between ethnically diverse and white students in 2020/21. In 2018/19, a higher proportion of ethnically diverse students engaged than white students.
- For engagement or not in 2020/21, the same factors were predictors of engagement as in 2018/19, except for ethnicity. Furthermore, in terms of course type, students on courses with no mathematics A level requirement were significantly more likely to engage.
- Whilst course type, age and nationality were predictors of repeat engagement in 2018/19 (courses with A level requirement were more likely to visit more often, whilst

mature and international students were likely to visit less often), only nationality was a significant predictor of repeat engagement in 2020/21.

5 The relationship between mathematics anxiety and mathematical resilience and MSS engagement

5.1 Introduction

In this chapter, the results of the MAMR questionnaire are discussed, as well as the prevalence of MA and MR amongst different demographic groups. A subset of this group with students primarily from the 2020 academic year was investigated in Gokhool et al. (2022). Identifying the MA and MR characteristics of the student population enables a better understanding of the impact of these characteristics on engagement with MSS. Furthermore, knowing about the MA and MR characteristics is helpful in analysing the outcomes of the MR intervention discussed in Chapter 6. This chapter aims to answer:

RQ2) What effect, if any, do MA and MR have on student engagement with MSS?

The sub-research questions are below.

SRQ1) Is there a significant difference between the mean MA and MR scores of different student characteristic groups?

SRQ2) What demographic and student factors, including MA and MR score, are predictors of engagement and repeat engagement?

SRQ3) What effect does engagement have on levels of MA and MR?

5.2 Methodology

Kooken et al.'s (2013) MR scale was used to determine students' MR levels. This questionnaire was chosen as the questions are applicable to university students, but not specific to any one course, and has been widely used by other researchers (e.g., Hutauruk & Priatna, 2017; Johnston-Wilder et al., 2014; Cousins et al., 2019; Hafiz et al., 2017). The questionnaire can be found in Appendix 1. There are a number of published scales for measuring MA (Hopko et al., 2003; Hunt et al., 2011), with most scales more commonly used with secondary school students. However, since Betz's (1978) scale has been used successfully with higher education students (Johnston-Wilder et al., 2014), it was chosen for use in this study. The MA and MR scale used can be found in Appendix 1.

Further questions to investigate how comfortable students were with the mathematics content in their course were also asked to students, adapted from questions found in Johnston-Wilder et al. (2014).

Average scores were calculated for MA and MR after ensuring negatively worded questions had been reverse-coded. One meant completely disagree, with five representing that students completely agreed with the statement. Three represented students neither agreeing nor disagreeing with the statement. Questions 3, 7, 10, 14, 18 and 22 were reverse-coded in the MR scale, whilst 1 to 5 in the MA scale were.

More details on this are provided in Chapter 3.

5.2.1 Sample

Whilst the questionnaire was open to any student at the university, the methods of advertising used meant it was primarily answered by students on courses with some mathematical content. Several of the responses were a result of students answering the questionnaires more than once. In these instances, the first submitted response was taken as the student's answer, and the other response was discarded. This gave a total of 669 responses received across two academic years, 2020/21 and 2021/22.

Student proctors were removed from the analysis, as were two students who had left all responses in the questionnaires blank. Students who were categorised as other gender (2), other ethnicity (16 students), in year 4 (2 students) or year 5 (1 student) were removed due to insufficient sample sizes. There were also missing values throughout which is a result of missing demographic data or incorrect student IDs, which were used to match the data.

Outlier values were calculated to be over 18.225 for student visits using the same method mentioned in Chapter 4. There were some outliers in the sample that were not erroneous values. To see how it affected the results, a one-sample t-test was again run with the mean of all visits made, (including the outlier visits) set as the test value (.674). The test returned $t(635) = -1.554$, $p = .121$. Without the outlier values, the mean number of visits was .531, so it is evident the outlier values did not significantly affect the mean number of visits. Thus, the three outlier values were kept in the analysis.

5.3 Results

The average MA and MR scores were calculated for all students. Scores ranged from one to five, with five denoting both high MR and high MA.

5.3.1 Descriptive statistics

The descriptive statistics for both scores are shown in Table 5.1.

Table 5.1

Descriptive statistics for MA and MR scores

Questionnaire	N	Median score	Mean score	SD	Minimum	Maximum
Mathematics resilience	506	4.00	4.00	.418	2.13	4.96
Mathematics anxiety	517	3.10	3.13	.846	1	5

The missing values i.e., the discrepancies in the value of N, are a result of some students not submitting a response for all of the scale questions; the scale questions were not marked as mandatory for students to answer.

A mean MR score of 4.00 indicates students overall have agreed with all of the MR questions (and given an answer of two to the negatively-worded questions). This relatively high score could be because a certain level of resilience is needed to engage with education at university level.

However, in the case of MA, there is much more variation amongst the scores, with both the minimum score of one (very low MA, if any), and the maximum score of five (very high MA) being witnessed in the data sample. Both the mean and median scores are around 3, which was the neutral option in the questionnaire, meaning students neither agreed nor disagreed with the statement.

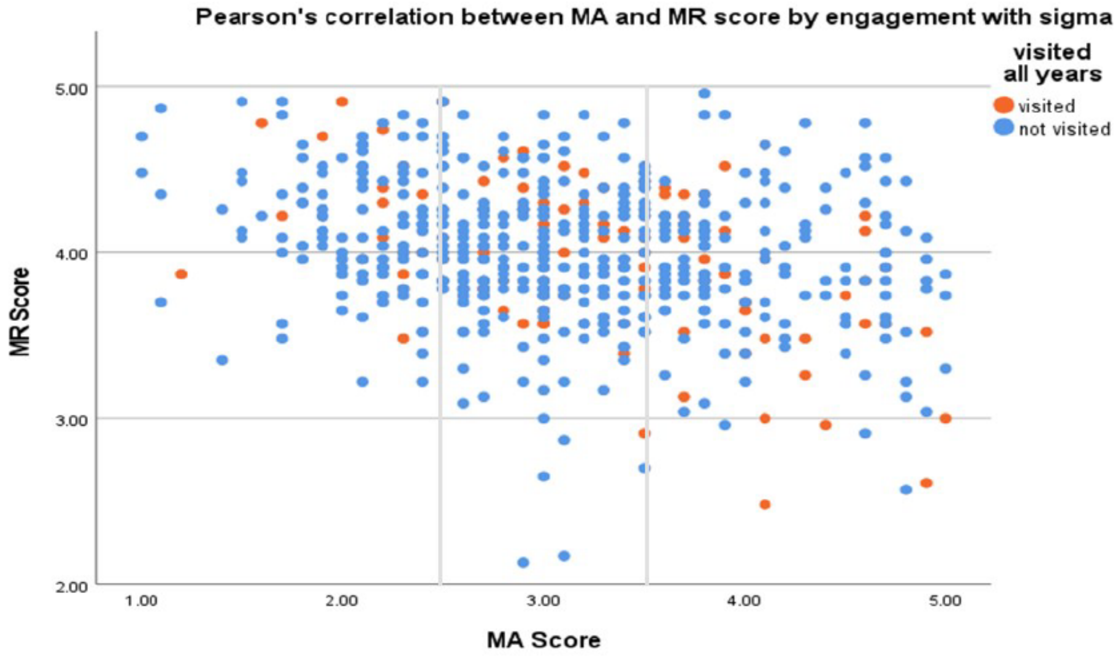
We may therefore conclude that, across this sample, the students are generally quite mathematically resilient and broadly neutral in terms of MA. However, there is of course individual variation, particular in terms of MA, where some individuals show high levels of MA and others show no MA at all, having either responded that they completely agreed or disagreed with all questions in the MA scale.

5.3.2 Correlation between MA and MR

A Pearson correlation coefficient was computed to assess the linear relationship between MA score and MR score. There was a significant weak negative correlation between the two variables, $r = -.253$, $p < 0.001$. This suggests that as MA increases, MR decreases, which is a notable result.

Figure 5.1

Correlation between students' average MA and MR score by engagement



For the purpose of interpreting Figure 5.1, each axis was divided into three regions: high, medium, low. This created nine "cells", for example, high MA and high MR (HH), high MA and medium MR (HM) etc. The cells are of unequal width since it is the meaning of the scores that have guided the division of cells. A score of 1-2.5 for MA suggested that students had either completely disagreed or disagreed to all of the MA questions, meaning they had low levels of MA, if any, and the opposite held true for scores of 3.5-5. However, a score of 2.5 to 3.5 indicated that students had mostly responded with the neutral option. For MR, since no students had an MR score of less than 2, the horizontal sections were split evenly to create those categories.

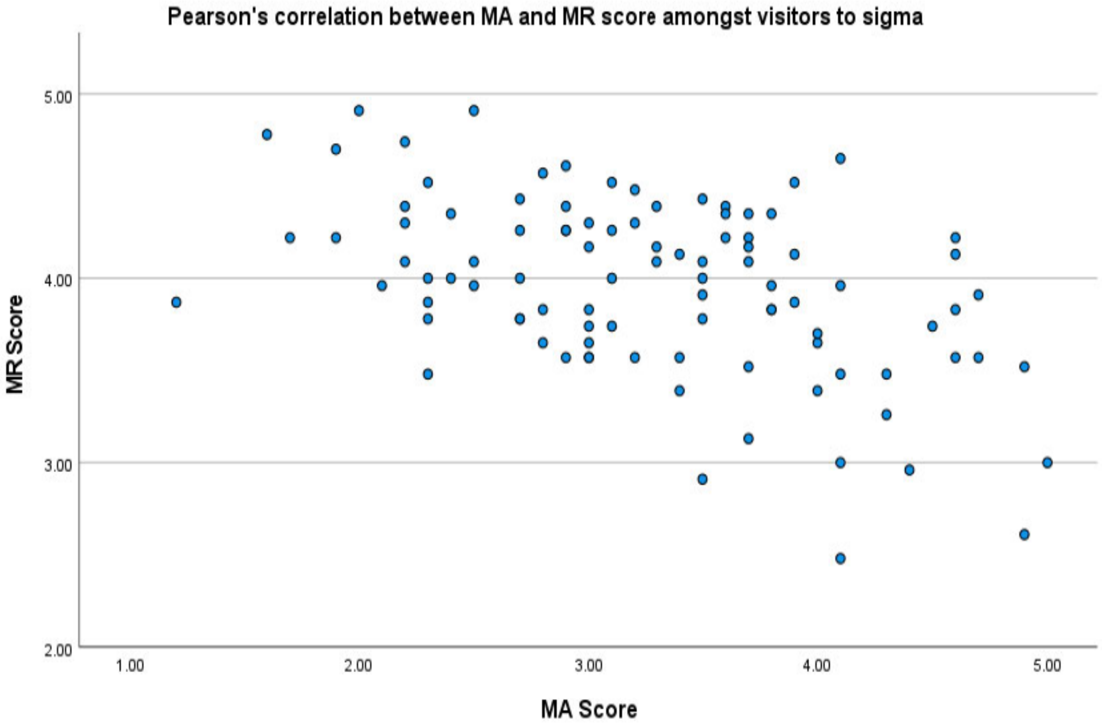
Students in the MH category engaged the most when considering the split of the cells. Their high levels of MR may mitigate their middling levels of anxiety and encourage them to seek support. This may similarly apply to those with a high level of MA too; however, it can be seen that students in the MH category engaged more than those in the HH category. This could be explained by the fact that whilst those with high levels of MR may already know and be comfortable with seeking support, their high levels of MA may mean they would rather seek support from their peers or online. This is further supported by looking at the engagement of those in the HM or HL category. With these students being less resilient, they may know of less avenues of support or not want to admit struggling with mathematics to their friends, and thus, seek support instead from **sigma** (particularly since most of **sigma** support was online during this time and so students were provided with a greater degree of anonymity) (Hodds, 2021).

No students in this dataset were in the LL section, and students with low anxiety also did not engage much with MSS. This is understandable since, for many with low MA scores, they will feel they do not need the support and are able to persevere with the mathematics in their course. It can be seen that as students' MR scores increase for those with low MA, visits also do increase. These findings cautiously indicate that, when we consider students with high levels of MR (>4), the relationship between MA, MR and engagement is similar to what was found by Wang et al. (2015) (displayed in Figure 2.2) for students with high levels of mathematics motivation: high levels of MR indicate high levels of motivation (Lee & Johnston-Wilder, 2017), and as found in Table 5.1, the sample of students in this dataset do have high levels of MR. However, for students with medium MR, there appears to be a monotonic increase in engagement as MA increases, whilst for students with low MR, there is not enough data to make any valid assumptions.

What is also curious is that whilst MA and MR were highly correlated when considering all students, when the analysis only included visitors, there was a stronger correlation. This can be seen clearer in the following two graphs.

Figure 5.2

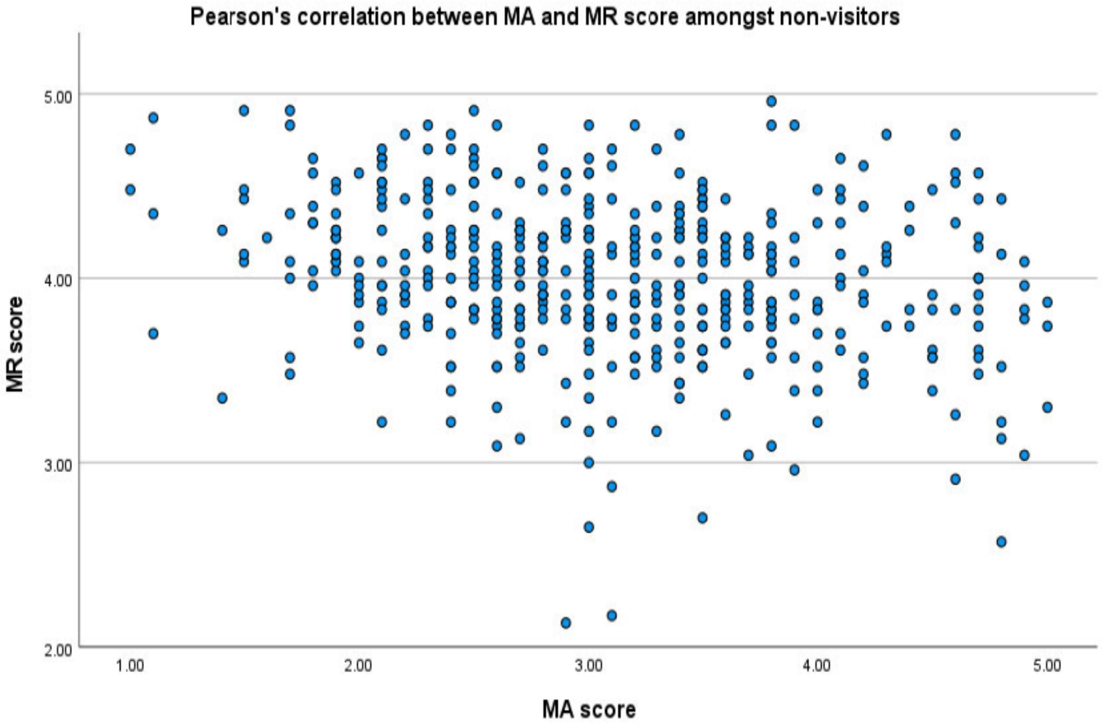
Pearson's correlation between MA and MR score amongst visitors



The reported result for visitors was r =-.470, p<.001.

Figure 5.3

Pearson's correlation between MA and MR score amongst non-visitors



The Pearson's correlation returned r=-.231, p<.001, so the MA/MR correlation was more pronounced amongst visitors. From Figure 5.2, there are very few students visiting that have low MA, and those that have visited also have high levels of MR. This perhaps indicates that whilst MA drives some students to engage, for others, as displayed in Figure 5.3, it does not. This difference may be for a multitude of reasons: perhaps there is another affective factor that also drives engagement, which is explored further in Chapters 7 and 8.

5.3.3 Correlation between MA, MR and visits to MSS

Four further Pearson's correlation analyses were conducted to determine the relationship between four pairs of variables: MA and visits, MR and visits, MA and visits excluding students who had not visited, and MR and visits excluding students who had not visited. These were all found to be non-significant except between MA and visits when excluding non-visitors (r=-.304, p=.045). This result indicates that whilst MA and MR did not usually have a relationship with visits to **sigma**, for those that had used the support in 2020/21, there was a moderate-to-weak negative correlation between their visits and their MA score. As their MA increased, their number of visits to **sigma** decreased, or alternatively, as their number of visits increased, their MA decreased. This relationship is depicted in Figure 5.4.

MA

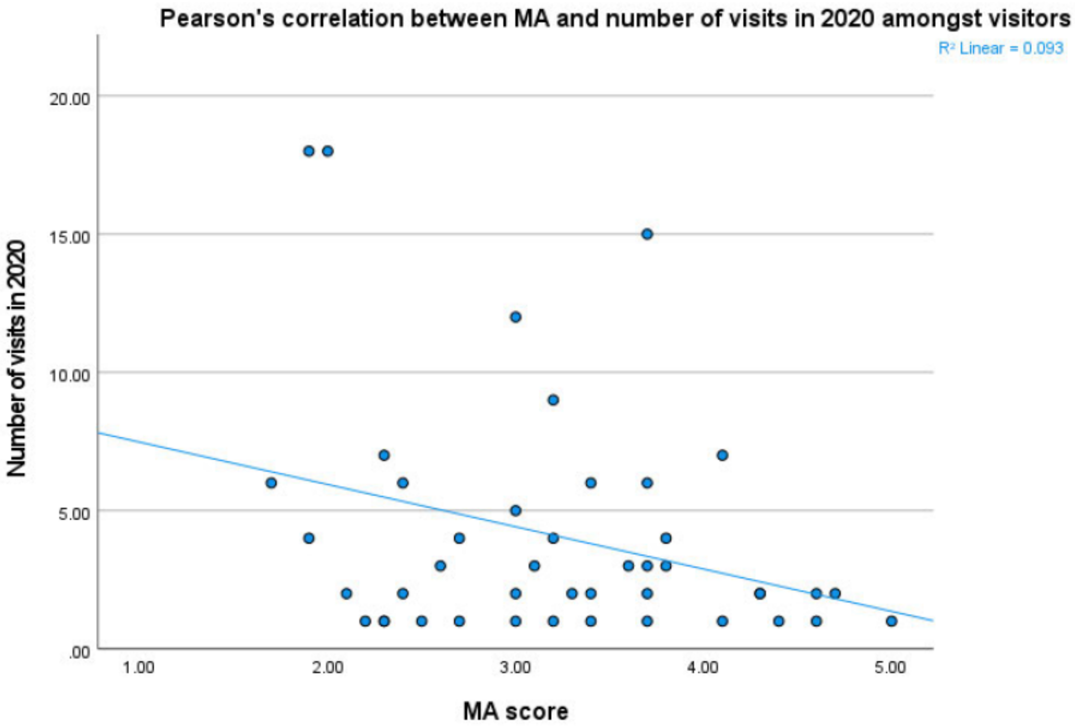
Table 5.2

Year of submission, type of visits, correlation coefficient and p-value for MA and number of visits to sigma

Year	Sample	Correlation coefficient	p-value
2020/21	Including non-visitors (N=606)	-.039	.332
	Excluding non-visitors (N=44)	-.304	.045
2021/22	Including non-visitors (N=606)	.017	.674
	Excluding non-visitors (N=68)	-.037	.762

Figure 5.4

Relationship between MA and number of visits among only visitors to sigma in 2020



Upon further inspection, it appears that the two students with low MA and a high number of visits may be skewing the results of this test, especially because it is a relatively small sample size. It can also be seen that there are students with higher levels of MA that have engaged with the service in 2020.

MR

As summarised above, there was no significant relationship that existed between the number of visits made to **sigma** and MR, even when year of visit was considered and non-visitors were removed from the analysis.

Table 5.3

Year of submission, type of visits, correlation coefficient and p-value for relationship between MR and number of visits to sigma

Year	Sample	Correlation coefficient	p-value
2020/21	Including non-visitors (N=587)	.017	.673
	Excluding non-visitors (N=42)	.285	.067
2021/22	Including non-visitors (N=587)	.037	.368
	Excluding non-visitors (N=67)	.042	.736

5.3.4 MA and MR by engagement and demographic characteristics

Since the data was normally distributed, independent sample t-tests were conducted amongst different student characteristic groups to determine if there was a significant difference between their mean MA and MR scores. The summarised results can be found in Table 5.4.

Table 5.4

Mean MR and MA scores are broken down by various characteristics and t-test statistics

Characteristics		N	SD	MR	t	p	N	SD	MA	t	p
Engagement	Not visited	418	.41	4.01	-.263	.792	426	.84	3.11	1.50	.135
	Visited	88	.44	3.99			91	.79	3.25		
Gender	Male	250	.41	4.06	-3.04	.003	251	.68	2.87	7.37	<.001
	Female	256	.42	3.95			266	.91	3.38		
Ethnicity	White	273	.40	4.01	.280	.779	278	.88	3.15	.606	.545
	Ethnically diverse	233	.44	4.00			239	.80	3.11		
Age	Non-mature	254	.37	4.06	3.21	.001	257	.75	2.93	-5.62	<.001
	Mature	252	.46	3.95			260	.89	3.33		
Disability status	No disability	427	.41	4.01	.001	.999	431	.84	3.07	-3.48	<.001
	Disability	76	.44	4.01			83	.82	3.42		
Nationality	Home	365	.39	4.04	3.22	.001	382	.85	3.21	3.56	<.001
	International	135	.46	3.91			135	.78	2.91		

These results show that, somewhat surprisingly, there was no significant difference between the MA and MR scores of students that had visited the centre as opposed to those that had not. However, those that did visit were more mathematically anxious (by .14) and less mathematically resilient (by only .02), though, as already noted, this difference was not significant. It may be that the relatively high MR scores of students helped mitigate the usual avoidance behaviour that is normally common in those with even moderately high (3) levels of MA (Dowker et al., 2016). It must be taken into consideration that there is a disparity in the number of students in each engagement category, which may affect the overall result too, although it is clear that there is no real difference in the MR levels between the engagement student groups for this sample. A larger sample size of engaged students may indeed find something different.

For gender, the total number of respondents was very similar, which made for more meaningful results. Male students were significantly more resilient (4.06) than female students (3.95).

Although there is more variability in the MA scores for female students, female students are significantly more mathematically anxious (MA = 3.38) than male students (MA = 2.87) (Durrani & Tariq, 2009). The middle score for MA is 3 and the female mean is above this value, so we might regard females generally as moderately mathematically anxious. On the other hand, the mean MA score for males is below 3 so we might regard males generally as less mathematically anxious. However, there may be a course effect at play here since female students in this sample were predominantly from courses with no mathematics A level requirement as discussed in Chapter 4.

Age was split into non-mature students (traditional students aged 18-21/22) and mature students. Non-mature students were significantly more mathematically resilient (4.06 to 3.95), which may be because they have not been away from mathematical education for quite as long as the mature students may have been. A similar trend can be seen in the MA scores of mature students too, which may be explained similarly (2.93 to 3.33). Although the mature students can still be considered as quite highly mathematically resilient, they are also somewhat anxious, though this may be offset by the value they can see in learning mathematics (Breen et al., 2015) which is one of the subscales of the MR construct (Kooken et al., 2013), and thus, they do still engage with MSS (as seen in Chapter 4).

Again, there was no significant difference in levels of MR between students with disabilities and those without, but again the disparity in group sizes must be noted. This overall similarity between groups in MR levels may be because to attend university, some level of MR is required. However, disabled students were significantly more mathematically anxious, which may be because of past difficulties with accessing adequate support. Whilst this group is not homogenous, it appears that those with a disability have significantly higher mean MA scores.

Ethnicity analysis, which is explored in further detail in the next section, revealed there was no significant difference in the MA or the MR score of either group. When considering nationality, students from the UK were considered home students, and all other students were grouped as international students. Home students were both significantly more mathematically resilient and more mathematically anxious. This may offer some commentary on the teaching practices of the country, where mathematics is seen as an important subject but also a difficult one that is not necessarily accessible to all students.

5.3.5 Ethnicity

Ethnicity had a number of categories, and for the purpose of the t-test analysis, students were split into one of two groups: white or ethnically diverse (which is any ethnic group that is not considered white). It must be reiterated here that this does by no means indicate that white students are the reference; the categories were split as such so that meaningful comparisons could be made around the engagement of ethnically diverse students with optional academic support. There was no significant difference found when the ethnicity groups were split in this way for either MA or MR score, meaning both groups were alike in scores. There were similar numbers of students in both groups and the variability in data was also similar. To investigate ethnicity further, the mean MA and MR scores can be found in the following table.

Table 5.5

Mean MA score broken down by ethnicity

Ethnicity	N	SD	Mean MA
White	278	.883	3.15
Asian	94	.639	2.94
Black	66	.810	3.00
Mixed	29	.702	2.98
Unknown	50	.907	3.65

Table 5.6

Mean resilience score broken down by ethnicity

Ethnicity	N	SD	Mean MR
White	273	.400	4.01
Asian	92	.435	4.00
Black	65	.476	4.02
Mixed	28	.314	4.07
Unknown	48	.461	3.93

The data in Tables 5.5 and 5.6 show that there is very little variability in MR across the different ethnic groups (4.00-4.07), but rather more variation in MA (2.96-3.16), with the exception of those with an unknown ethnicity (3.93 for their MR score and 3.65 for their MA score). In particular, Asian and white students have virtually identical MR scores (4.00 and 4.01), but their MA scores are quite different (2.94 and 3.15). Those with an unknown ethnicity have a considerably higher MA score than any other ethnic group, and their MR score is also relatively low.

Since Asian students had the lowest MA, a t-test was conducted to determine whether the difference in MA between Asian students (2.94) and non-Asian students (3.18) was significant, which returned t (180.98) =-3.05, p=.003, meaning Asian students are significantly less MA than the other amalgamated groups. However, when a t-test was run to measure the difference in MR, as expected, there was no significant difference in the MR score of students based on ethnicity.

5.3.6 Course type

Students from a multitude of courses responded to the questionnaire, but for practical reasons, it was decided that courses should be amalgamated into one of three categories based on the mathematical prerequisites of their chosen course in the same manner as Chapter 4.

Table 5.7

Mean anxiety score broken down by course type

Course	N	SD	Mean MA
No A level Mathematics requirement	316	.878	3.34
A level Mathematics recommended	51	.646	2.93
A level Mathematics required	146	.672	2.75

Table 5.8

Mean MR score broken down by course type

Course	N	SD	Mean MR
No A level Mathematics requirement	306	.424	3.93
A level Mathematics recommended	50	.384	3.98
A level Mathematics required	146	.359	4.17

Perhaps as expected, students on courses with a mathematics A level prerequisite are the least mathematically anxious (2.75) and have the highest MR score (4.17). As the requirement drops to a recommendation and then to not needed, the MR score subsequently decreases as the MA score of the respective groups increases, though it is interesting to note those on courses with no requirement or recommendation still have quite a high MR score (3.93). This indicates that course type does have an effect on MA and MR scores. To ascertain whether this difference was significant, a one-way ANOVA was performed to compare the effects of course type on both MA and MR scores. This revealed that there was a significant relationship between the MA score of at least two groups $F(2, 510) = 29.197$, $p<0.001$ and the MR score of at least two groups $F(2, 499) = 17.901$, $p<.001$. A post-hoc Bonferroni correction was conducted, which identified that the mean difference between the MA of A level required and no A level required was significant, with $p< .001$, 95% C.I. = [-.789, -.403]), and between no A level Mathematics requirement and A level Mathematics recommended ($p=.002$, 95% C.I.= [.119, .702]). A Bonferroni correction was chosen rather than a Tukey HSD because not only is it more rigorous, but it also does not rely on the assumption that all sample sizes are the same (Lee & Lee, 2018). Furthermore, "of the two, Bonferroni has more power when the number of comparisons is small, whereas Tukey is more powerful when testing large numbers of means" (Field, 2013, p.459). No significant difference existed between the groups of A level Mathematics required and A level Mathematics recommended ($p=.471$).

When considering MR, a significant difference in means existed between A level maths recommended and A level maths required ($p=.012$, 95% C.I. = [-.349, -.033]) and between A level Mathematics required and no A level maths required, with $p<.001$, 95% C.I, [.144, .339]. However, there was no difference in mean MR score for students on a course where an A level in mathematics was recommended and one where there was no requirement ($p=1.00$).

It is necessary to clarify here that although a student may be on a course with no mathematics A level requirement, they may still have studied A –level mathematics (or equivalent). Future analysis between students' actual prior qualifications and their MA and MR score may be beneficial, but it is believed that similar results would be found.

5.3.7 Course stage

The mean MA scores amongst the different course stages can be seen in Table 5.9. There did not appear to be great differences between the MR scores of all three years, and the only year with a markedly different MA score from the others was course stage 3. This can be potentially explained by third-year students having projects that involve statistical or mathematical analysis, which they may not have had much content on in the previous two years. Additionally, the third year is arguably the most important of the academic years, which may also contribute to student stress and increase general anxiety. This may contribute to an increase in MA as the year progresses (Yurtcu & Dogan, 2015).

Table 5.9

Mean anxiety score broken down by course stage

Course stage	N	SD	Mean MA
1	191	.832	3.12
2	291	.851	3.13
3	35	.902	3.23

Table 5.10 below details the mean MR score amongst the different course stages.

Table 5.10

Mean resilience score broken down by course stage

Course stage	N	SD	Mean MR
1	190	.420	3.97
2	281	.415	4.02
3	35	.431	4.07

Whilst there is not much difference between the MR scores, it can be seen that as students progress through their course, their MR score does increase incrementally, which may be because they have come to realise the importance of mathematics and statistics to their subject, where seeing the importance of mathematics is on the value subscale of MR. Notably, from Stage 1 to Stage 3, MA and MR increase by approximately the same amount (0.11 and 0.1 respectively).

5.4 Statistical modelling

An ANCOVA was conducted to determine which factors affected MR and MA scores, whilst also taking into account that a significant correlation existed between MA and MR. MA and MR were added as covariates to each respective model.

To determine what affected visits to **sigma** when considering student characteristics and MA and MR scores, a hurdle model was used.

5.4.1 Mathematics Anxiety

It is important to measure normality particularly when analysing small datasets to determine whether to proceed with parametric or non-parametric testing. The Shapiro-Wilk test is used to measure whether the data follows the normal distribution.

As such, residuals were first tested for normality using a Shapiro-Wilk test, which was found to be non-significant. Levene's test of equality of error variances also returned a non-significant value of p=.194. MA was added as the dependent factor for the following model, with MR added as a covariate. When all factors (engagement, gender, course, age, ethnicity, nationality and disability) were in the model, age, ethnicity and gender were non-significant. They were subsequently removed from the model and the analysis was re-run. For course, A level Mathematics required was used as a reference category. Further statistical detail can be found in Table 5.11.

Table 5.11

β and p-values for reduced ANCOVA model for MA

Parameter	β	p-value
Visited	.212	.028
Disability	.286	.005
No A level maths requirement	.406	<.001
Mathematics a level recommended	.154	.230
International	-.268	.002
MR score	-.458	<.001

Here, β represents the change in the MA score as there is a change from the reference category to the next (for example, moving from not visited to visited), with all other predictors being held constant. After removing non-significant factors from the model, it was found nationality, course type, engagement and disability all had a significant effect on MA score. Those that had engaged with **sigma** had higher MA scores than those who did not visit. However, though engagement was significant at the .05 level, there is only a change of .2 in MA as a student moves from not visiting to visiting MSS, which should be remembered when considering the other β coefficients, too. This is not a large change, and practically, this does not give much information. Although the t-tests conducted earlier showed that those who visited had a non-significant lower MA score, the opposite finding here can perhaps be explained by the controlling of the other factors in the model, which the t-test does not take into account.

International students had a significantly lower MA score, whilst disabled students had a higher MA score than non-disabled students, and those on courses with no A level Mathematics requirement or those that recommended a mathematics A level were also significantly more anxious than those on a course with an A level Mathematics requirement.

5.4.2 Mathematical Resilience

Engagement, disability, gender, year of birth, and ethnicity were all non-significant in the initial model for mathematical resilience. The model without these variables can be seen in Table 5.12.

Table 5.12

β and p-values for reduced ANCOVA model for MR

Parameter	β	p-value
No A level maths requirement	-.183	<.001
Mathematics a level recommended	-.129	.047
International	-.171	<.001
MA score	-.117	<.001

The factors that significantly affected MR scores were nationality and course type. International students had a significantly lower MR score, though this difference was only by -.13 (from Table 5.4), which again, is not a large change. As expected, students on a course with a mathematics A level requirement were more mathematically resilient than those on the other two course types, though the difference with those that are on courses with an A level in mathematics being recommended was only borderline significant ($p=.047$).

5.4.3 Engagement with MSS

The next model focused on the factors affecting engagement with MSS, with visits as the dependent variable. As in Chapter 4, a hurdle model was used due to the inflation of the zero count data, and so that it could be measured whether a difference exists in the factors that affect engagement with **sigma**, and repeat engagement with **sigma**. The frequency of visits can be seen in the following table, as well as the clear disparity in zero-count data and positive count data.

Table 5.13

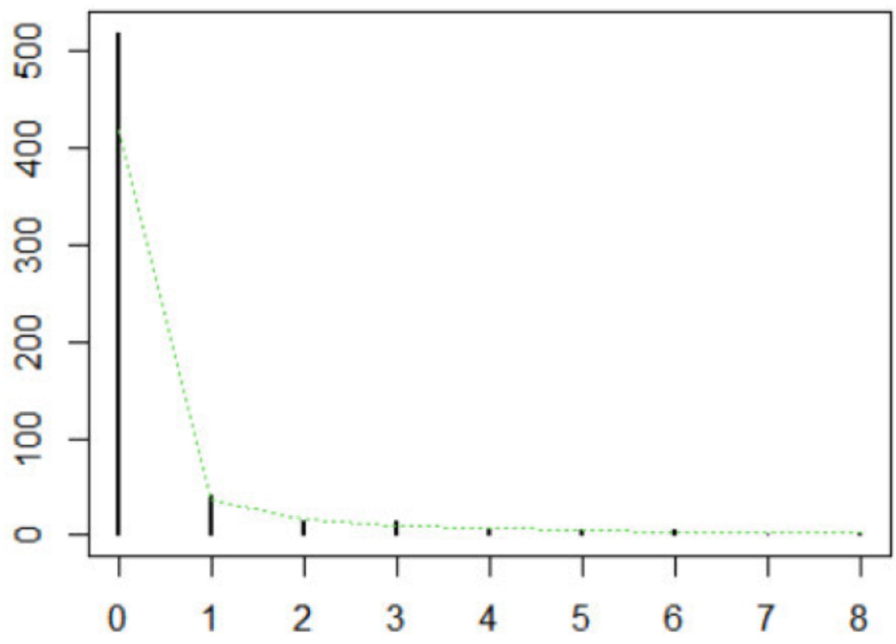
*Number of visits made to **sigma** by students who completed the MAMR questionnaire*

Visits	0	1	2	3	4	5	6	7	8	9	11	12	14	18	19	43
Frequency	520	41	14	14	8	5	4	1	3	1	1	1	2	1	1	1

To ensure a close-fitting model to the actual visit data, a number of distributions were tested, with a negative binomial model fitting the data best as in Chapter 4. This is demonstrated in Figure 5.5.

Figure 5.5

Hurdle model with a negative binomial distribution (green dotted line) fitted to actual visit data from MAMR questionnaire participants (black lines)



The necessity of the hurdle model is firstly evident from this figure, as is the relatively close fit of the model. The results from the second part of the model (zero count data) will be discussed first. Again, what is displayed is a reduced model as in Chapter 4 as non-significant variables were removed in turn and log-likelihood scores were compared to determine changes in the model fit, with the displayed model presenting the best fit of the data.

Table 5.14

Hurdle model measuring engagement with MSS by different characteristics, MA and MR score

Categories	B	e^{β}	p-value
Ethnically diverse	0.523	1.687	.028
Mathematics A level recommended	-.159	.853	.685
No mathematics A level required	-.858	.424	.002
MA score	0.402	1.495	.010

MR score, gender, age, disability, and nationality did not return significant p-values, indicating that they did not predict visits made to **sigma** by these students. The MA score being statistically significant shows that changes in MA score are associated with changes in the probability that a visit is made to **sigma**. The odds ratio value (1.5) is greater than 1 indicating that the odds of a visit occurring increases as MA score increases. For each 1 unit increase in MA score in a student, the odds that they visit increase by approximately 1.5 times. For the categorical predictors in the model, i.e., course type and ethnicity, the odds ratio is comparing the odds of a visit occurring as the value of the predictor changes when controlling for the other predictors in the model. For course type, mathematics A level required was chosen as the reference category. e^{β} for both of the other course types were less than 1, indicating that a visit was significantly less likely for students on courses with no mathematics A level requirement. However, in the case of ethnicity, the odds ratio for ethnically diverse students was greater than 1, showing that a visit was more likely to be made by ethnically diverse students.

For the positive count data, all variables returned p-values greater than .05, meaning none of the variables were significant predictors of the rate of visits made.

5.5 Discussion

In Gokhool et al. (2022), a subset of the questionnaires discussed within this chapter was analysed. The responses included were primarily from the academic year of 2020/2021, whereas the dataset analysed in this chapter also includes data from the 2021/22 academic year. A summary of the findings from the paper is now shared. The same characteristics were included in the model aside from nationality as this data was not available at the time. Course type and engagement significantly affected MR levels during the pandemic, where those that visited had lower levels of MR interestingly and those on courses with a mathematics A level requirement had significantly higher levels of MR than those on courses with no such prerequisite. When MA was investigated, disability and course type again were found to be significant predictors.

However, for the whole dataset investigated in this study, statistical analysis conducted on the questionnaires revealed that a myriad of factors affected MA prevalence in students. Whilst the t-tests showed that gender and other factors individually seemed to influence MA scores, the ANCOVA provided a different story. Since the ANCOVA took into consideration all factors within the model including the MR of students, the results from this will now be discussed.

Engagement with MSS was found to be significantly related to student levels of MA. When controlling for all of the factors, those that engaged with MSS were found to have higher MA scores. It must be added as a disclaimer here that whilst some students' MA may encourage their engagement, there may be other students who find that their MA hinders them, particularly since the significance level returned in the ANCOVA just reached significance. This is discussed further in Chapter 8.

Course type was also a significant predictor of engagement with students on courses with no A level requirement having significantly higher levels of MA, though no significant difference existed with those on courses with just a recommendation for A level Mathematics. This was perhaps expected since the literature points towards students with high MA avoiding mathematics (Dowker et al., 2016), and as such, these students are unlikely to choose courses at university that would require an A level in mathematics. However, as can be seen in the results, though the difference is significant, students on courses with a mathematics A level requirement do not have negligible levels of MA, which may be considered to be between the score of 1 and 2. In actuality, the mean MA for these students is 2.76, which is close to the overall mean score for student levels of MA in this sample. Students on courses with no mathematics prerequisite also had significantly lower levels of MR than those on courses with a requirement. Students with high levels of MA and low levels of MR are those that are at risk of failing to avail of support as they may not have the necessary structures in place to guide them to help when needed and their MA may also prevent them from seeking support. Course type was found to be a predictor of both MA and MR when a subset of this dataset was analysed in Gokhool et al. (2022).

Somewhat surprisingly, gender was not found to be a significant predictor of MA unlike what has been found by several researchers (Johnston-Wilder et al., 2014; Durrani & Tariq, 2009; Joyce et al., 2006; Mutodi & Ngirande, 2014). This may show that it is in fact the interaction of other factors along with gender that are significantly impacting levels of MA and thus, in this model where other factors are controlled for, gender does not appear as significant. It could be that the reason gender has not appeared as a statistically significant factor is because it is interacting with one of the other factors. This may be course type where courses with no mathematics A level requirement tend to be highly populated with female students in CU as seen in Chapter 4. Again, this is somewhat convoluted since female students may have taken courses such as Biomedical Science and Psychology because of the perceived relative absence of mathematical content. Courses with no A-level requirement also have higher levels of MA overall (β =.406, $p<.001$ in Table 5.11) so this factor in the model captures part of the gender effect. In Table 5.4, MR is also significantly higher amongst male students, so again, including MR in the ANCOVA model also captures other aspects of the gender effect on MA, since those with higher MR have lower MA (β =-.458, $p<.001$ in Table 5.11).

Nationality was also returned as a significant factor, with the β-value suggesting that international students have lower levels of MA than home students. The culture around mathematics differs by country. In certain counties, particularly western countries, mathematics may be seen as innately difficult, and this can contribute to the higher anxiety around the subject. Indeed, in a survey conducted across 20 countries, it was found that the UK had the highest prevalence of MA (Cuemath, 2021), with this being attributed to the traditional mathematics teaching that is commonplace in the UK. Johnston-Wilder and Lee (2010b) goes so far as to say that mathematics education practice in the UK is a form of cognitive abuse. However, home students had significantly higher levels of MR than international students, which may be because despite the mathematical teaching practice emphasising that it is a struggle to learn mathematics, the importance (and thus value of the subject) is also reinforced. Therefore, although students may be mathematically anxious, they are aware of its importance, and have a culturally-skewed perception of its level of difficulty. As Lau et al. (2022) found, students in countries with higher levels of MA are more likely to achieve a lower mathematics result, and that the MA levels of students' peers also predict their achievement. Since the UK is extremely MA, this is of concern. This contextual effect extends to homes and schools, and in England, this effect is particularly strong, which is supported by the findings from this study, with home students being significantly more MA than international students.

Whilst there was virtually no difference in the MR scores of those with disabilities to those without, students with disabilities did have significantly higher levels of MA as was found in Gokhool et al. (2022). It is worth noting here that in Cliffe et al.'s (2020) accessibility survey, MA is reported as a student accessibility barrier seen often by MSS practitioners in students, but it is not one in this analysis and would not be included as a disability. Although it can be seen here disabled students have higher levels of MA, in Chapter 3, it was found they were significantly more likely to engage than their counterparts, consistent with what has been discussed in this chapter about those with higher MA being more likely to visit MSS.

The hurdle model considered visits as the dependent factor. Interestingly, no factors were shown to be significant predictors of the rate of student visits, despite nationality having significantly predicted the rate of visits in Chapter 4 in 2020/21. Whether this is due to the smaller sample size of students (which is still sizeable), or due to the inclusion of MA and MR in the model is unclear, though even when MA and MR were removed from the model, the demographic factors still did not show significance.

When looking at the part of the model that processed the zero count data i.e., whether a student had engaged at least once, MA, ethnicity and course type were all found to be significant predictors. After controlling for the other factors in the model, including the MA score of students, it was found that ethnically diverse students were approximately 1.7 times more likely to visit than white students, providing further evidence that the engagement of ethnically diverse students with university support does not contribute to the awarding gap. As Panesar (2017) stated, using university data to challenge such assumptions is of paramount importance, and this finding is key since it shows that even after accounting for differences such as gender, levels of MA, and course, as in Chapter 4, ethnically diverse students are still engaging significantly more. Further research on what encourages ethnically diverse students to engage would be of interest, as well as whether white students are at all being hindered from using the support.

Since the differences in MA across courses had been particularly notable, and course type was also a significant predictor of engagement in Chapter 4, the interaction between the two was assumed to be quite high, and so it is interesting to note that even after MA was accounted for in this model, course type was still a significant predictor of engagement. Students on courses with a mathematics A level requirement engaged significantly more than students on either of the other course types, highlighting that more research here is necessary. Whilst it may be explained by the fact that students on these courses have less mathematical content, this part of the model only looks at initial engagement, not repeat engagement, and as such, it may be that some students are feeling intimidated by MSS and not seeking support.

Finally, and perhaps most importantly, it was found that students with a one-point increase in their MA score were approximately 1.5 times more likely to engage once with the support. Where MA has been noted to hinder engagement with mathematics (Dowker et al., 2016) there was an assumption that it would also hinder engagement with MSS, though no known research had yet been conducted to measure this. However, this assumption has now been challenged within this study. It appears that feeling anxious around mathematics is prompting students into engaging, and as such, MSS staff should continue to ensure measures are taken to encourage these students to seek support where deemed necessary. This may be because as students build their resilience and "widen" their growth zone (Johnston-Wilder, 2018), they may fall into the danger zone, which is where some of them turn to **sigma** for support.

5.6 Summary

The aim of this chapter was to show whether a difference existed in MA and MR scores of both users and non-users of MSS, how engagement with **sigma** affected MA and MR, as well as what the prevalence of MA and MR is amongst different demographic groups. Course mathematics entry requirements, nationality, engagement and disability all had a significant impact on MA score, whilst nationality and course type appeared to significantly affect MR score. Despite t-test analysis stating a significant difference by gender in MA scores, it did not return as significant in the ANCOVA model, thus suggesting a relationship between gender and other factors in the model. The ANCOVA also showed that, when other variables in the model were controlled for, those that engaged with **sigma** had significantly higher levels of MA. The hurdle model analysis supported this hypothesis, showing that even once other factors were accounted for, an increase in MA would significantly increase engagement with **sigma**, which is another novel finding in this research. The overall MR levels of students in this sample are high and this may be contributing to the unexpected results about an increase in MA increasing engagement, since those with higher levels of MA have a higher need of MSS and their MR levels are also high enough for them to seek out support.

The key findings are summarised below. It is important to remember these are overall findings from data that was collected both during and after the pandemic.

- Engagement with **sigma** appears to mostly have an inverted U relationship with MA and MR, though the significance cannot be measured due to its nature. The only exclusion to this is students that have low MR and low MA, who did not engage with **sigma** at all, so it cannot be said that these specific students follow this pattern. For high MR, engagement has a modified inverted U shape relationship as MA increases, whilst for medium MR, there is a monotonic increase as MA increases. For those with low MR, there is not enough data to draw conclusions about the relationship with engagement and MA.
- There is a significant weak negative relationship between MA and MR.

- Engagement, disability status, course type, and nationality all significantly predict MA score when other factors were controlled for.
- Engagement with **sigma** predicts a higher MA score.
- Course type and nationality predict MR score when controlling for the other factors.
- Ethnicity predicts student engagement when other factors, including MA, are controlled for, with ethnically diverse students engaging significantly more.
- As in Chapter 4, course type also significantly predicts engagement.
- Interestingly, MA score also predicts engagement, with students with a higher MA score engaging significantly more.
- Disability is a borderline significant factor in predicting repeat engagement when other factors, including MA and MR, are controlled for. More investigation would be of interest.

6 The effectiveness of a mathematics anxiety intervention in promoting engagement with MSS

6.1 Introduction

Lyons and Beilock (2012, p. 2102) state, "Educational interventions emphasizing control of negative emotional responses to math stimuli (rather than merely additional math training) will be most effective in revealing a population of mathematically competent individuals, who might otherwise go undiscovered". This chapter considers the delivery and analysis of such an intervention that aimed to address any struggles students may have with MA through sharing methods to increase their MR. The intervention was developed based on existing resources (Johnston-Wilder et al., 2020; Johnston-Wilder, 2018), with permission granted by the creator to use the resources in this manner. No mathematics or statistics teaching was included in the intervention so as to encourage students to engage with it since it is acknowledged that MA inhibits engagement with mathematics. This chapter aims to address RQ3:

RQ3) What is the effect, if any, of developing students' levels of MR on their engagement with MSS?

The sub-research questions it aims to answer are:

SRQ1) How does the intervention affect students' MA and MR levels?

SRQ2) What impact does the intervention have on engagement with MSS – does high MA hinder engagement, and does high MR encourage engagement?

SRQ3) What is the difference in impact on MA and MR between online and face-to-face delivery?

SRQ4) Is the intervention a viable solution to increasing the engagement of MA students with MSS?

The key quantitative variables explored in this chapter were MR scores, MA scores and number of student visits to drop-in MSS.

The chapter will begin by describing the contents of the intervention, followed by the sampling techniques and sizes. Permission to use and adapt lesson plans and resources was granted by the author, Sue Johnston-Wilder. A brief explanation of the methodology used for both the delivery and analysis of the intervention will also be shared before detailing the results from the analysis.

6.2 Methodology

6.2.1 Design

A pilot intervention was first delivered to two Computer Science students, which consisted of three one-hour online sessions for the purpose of understanding if changes needed to be made to the delivery. The researcher had shared details of their research and of the benefits of **sigma** during a Computer Science induction talk, and following this, two students got into contact. One student asked to take part in the intervention explicitly since they had failed their mathematics module and were resitting their semester, whilst the other was seeking a place to work on their mathematics and was later recruited. Following the pilot intervention, it was clear that three sessions were unnecessary and that the content could be adjusted to fit the availability of students and/or lecturers. The feedback from the pilot was helpful in planning the timings and content of the intervention.

The intervention was delivered either face-to-face, in which case students' lecturers were present, or online via MS Teams. Sessions lasted between one and two hours as planned for after the pilot.

Students completed the MAMR questionnaire before and after the intervention to determine its effects on their MAMR scores. Further details of the MAMR questionnaire and its design can be found in the methodology chapter (Chapter 3.3.1). After the intervention, students also completed several questions which asked for their feedback on the sessions, and their likelihood of engaging with MSS after the intervention. Students completed the post-intervention questionnaire at different times to one another as this was dependent on when their lecturers shared the questionnaire with them. They answered the post-intervention questionnaire around 1 week to 6 months after the intervention, which, for some students, coincided with their assessment/exam period. This variation in response times was an unfortunate happenstance since the researcher could only prompt the students into answering the questionnaire and not invite them to answer on a particular date. The qualitative responses were analysed using a general inductive approach (Thomas, 2006), as described in the general methodology chapter.

6.2.2 Intervention content

The intervention was modified from materials shared in Baker (2021); Johnston-Wilder et al., (2020); Johnston-Wilder (2018). As the aim of the intervention in this study was to increase student engagement with **sigma**, it was necessary to amend the materials to also share details on the provision of MSS at Coventry University.

The intervention started by asking students to share what they thought the definitions of MA and MR are. These answers were discussed before the actual definition for the terms was shared. To be mindful of the fact that students may be susceptible to leaving the online intervention before completion (Hazra & Priyo, 2022; Muslimin & Harintama, 2020), an overview of the intervention contents was first provided. This was because, although not many changes were suggested during the pilot run of the intervention, it was said that some of the content should be rearranged. Students mentioned having the strategies to reduce MA might be more beneficial in the first session (when the intervention was run over three sessions). Students were also given copies of the slides after the intervention as this was also mentioned during student feedback.

The first technique shared with students was that of the hand model of the brain. This is a resource from Siegel (2010) that aims to show students the "mind freeze" that sometimes accompanies studying mathematics is simply a defence mechanism their body is implementing because it sees mathematics as a threat. It was reinforced to students that the brain was incapable of differentiating between a social and physical threat, so mathematics could be seen as a threat in the same way a tiger may be considered one, which would cause the brain to "flip offline". This was shared in the hopes of moving focus away from the "deficit model" where it is felt that students are to blame for their lack of success in learning effectively. An explanation of the hand model of the brain can be found in more detail in Johnston-Wilder et al., (2020, p. 1424), with the diagram used in the intervention displayed in their paper in Figure 1(a).

It was now felt essential that the techniques that can be used to "switch off" this fear of mathematics should be shared. There was a concern that students may see the hand model of the brain and feel as though this condition was permanent and nothing could be done about their MA. Techniques shared by other researchers in the field, which are summarised by Johnston-Wilder et al. (2020), were the primary methods explained to students, as well as the mechanism behind why they were effective. Johnston-Wilder also explained the content of the interventions over virtual meetings with the researcher and shared advice about its delivery. Students at this stage were asked to share any strategies that had worked for them to calm any anxious thoughts that were not necessarily about mathematics. These strategies were added to the PowerPoint slides to show students their suggestions were valid. For later sessions, student suggestions were italicised to show that it was in fact other students who had tried-and-tested those particular methods.

The next model shared with students was the growth zone model (Johnston-Wilder et al., 2020), which can be seen in Figure 6.1.

Figure 6.1

Growth zone model

Johnston-Wilder et al. (2020)

It consists of three concentric zones, with the growth zone model sitting between an inner comfort zone, and an outer anxiety (panic) zone. In the comfort zone, students are likely to be working on topics they are knowledgeable on, and therefore feel comfortable with. They will be building fluency in these areas, but not learning many new concepts or skills. Most learning takes place in the growth zone where there is a need for active thinking but the student does not feel too threatened or distressed by the teaching content. The anxiety zone is where no real learning is taking place as it is when a student is too anxious about the possibly unfamiliar content they are faced with (Siegel, 2010). This is the zone where the brain has perceived the subject as a threat and "flipped offline", and as such, students may procrastinate to avoid the 'stressor' or even become angry or upset. Being in this zone is temporary.

One can expand the growth zone through increasing resilience; for students to achieve this, they were told to reflect on any experiences, inside or outside of mathematics, with learning and identify at what times they were in each of the zones. Students shared what their physiological reactions were in each of the zones. It was hoped that doing so made them better able to identify what zones they were in during their future learning experiences. It was reinforced that since the brain had 'flipped' off when students were in the danger zone, forcing themselves to try to learn at this point would not be effective. They were advised instead to use the strategies shared earlier in the intervention to reduce anxiety so that, after taking a short break, they would have moved back from the danger zone to the growth zone and therefore be better equipped to deal with the task at hand. It was about training the brain to no longer perceive mathematics as a threat.

The last model shared with students was the ladder model (Johnston-Wilder et al., 2018). Each step is a rung in the ladder, with gaps indicating support may be needed to progress to the next rung.

Figure 6.2

Ladder model

Some materials have been removed from this thesis due to Third Party Copyright. Pages where material has been removed are clearly marked in the electronic version. The unabridged version of the thesis can be viewed at the Lanchester Library, Coventry University.

Johnston-Wilder (2018)

This model shows that effective learners are not those who have all the answers readily available to them; rather, it is those that know how learning can be broken down into manageable steps and follow these steps. Resources that can help a participant achieve this, such as lecturers, books, online tutorials and MSS, were outlined. Since the original intervention was not aimed at increasing engagement with MSS, at this stage, information around the services available to students through **sigma**, such as the online resources, the one-to-one appointments, and the drop-in services, were shared. Students were told this was one such way they could break down their learning and were reassured that the staff at the centre were non-judgemental and would be able to help with most queries, even if the mathematics was course-specific.

Throughout, where time was available, students were encouraged to share their experiences with mathematics so that they were able to see where their fear stemmed from and to make it clear that they were not alone in their experience.

Finally, links to mental health support were discussed to ensure students felt supported and knew help was available if they wished to discuss how they felt further, particularly because of the sensitive topics discussed.

6.2.3 Participants

Fifty-one students participated in the intervention. Fifty of these answered the pre-intervention questionnaire and 22 answered the post-intervention questionnaire. Participation was voluntary and students were promised they would not be asked (or taught) any mathematics during the intervention.

Most students were from one of three courses: Biomedical Science, Analytical Chemistry, and Computer Science as lecturers from these courses had agreed to promote the intervention with their students. The author aimed to primarily target those on non-mathematical courses as traditionally, it is these students that do not engage with MSS and may have high MA (Gokhool et al., 2022). However, those on mathematical courses were not excluded from participation. Indeed, those on these courses did not always have high levels of

MR or low levels of MA when individual scores were checked in the previous chapter (Chapter 5), a misconception that many may hold but can be very damaging to students on these courses.

6.2.4 Procedure

The author led the intervention for all the students, although there were different group sizes that ranged from 1-16 students. The length of the intervention also differed from 1-2 hours depending on student availability.

There were two main ways of signing up to the intervention. Those in the face-to-face group signed up during their regular lecture hours as the intervention was delivered during the lesson. Those that had taken part online had either emailed the researcher registering their interest in the intervention after hearing about it during lecture shout-outs or advertising emails, or they were contacted by the researcher after they had agreed to be emailed information about the intervention when completing the MAMR questionnaire. Coincidentally, all online participants had emailed the researcher displaying interest in the intervention and, for those that participated once lockdown restrictions were over, still chose an online intervention over a face-to-face one.

The participant numbers of those who completed the post-intervention questionnaire (excluding one participant who did not complete the pre-intervention questionnaire correctly) have been added in the following table, along with the date of intervention, number of attendees, form of delivery, length of intervention and course of study. The participant numbers were allocated in the order that the post-intervention questionnaires were received. Course titles have been shortened.

Table 6.1

Details of intervention delivery and participants' course of study

Date of intervention	Attendees	Participant number	Course	Length of intervention	Form of delivery
15th Feb 21, 22nd Feb 21, 1st/4th Mar 21	2	1,2	Com Sci	1 hour	Online
22nd Mar 21	1	3	Eng	1 hour	Online
7th Oct 21	12	8, 14, 15, 16, 17, 18	Bioscience (year 1)	2 hours	Face-to-face
11th Oct 21	12		Chemistry	2 hours	Face-to-face
13th Oct 21	16	5, 6, 7, 9, 11	Bioscience (year 2)	2 hours	Face-to-face
25th Nov 21	1	4	Com Sci	2 hours	Online
10th Feb 22	5	10, 19, 20, 21	MSc Psych (2), Adult Nursing, Com Sci	1 hour 30 minutes	Online
14th Feb 22	1	12	Adult Nursing	1 hour	Online
9th Mar 22	1	13	PhD	1 hour	Online

No students from analytical chemistry completed the post-intervention questionnaire. It may be assumed that those in this course were less motivated to complete the questionnaire as they were not as anxious as the Biomedical Science students, with both interventions being run during lecture time. However, the more likely reasoning is that the lecturer who held the session perhaps did not remind their students to complete the questionnaire, whereas the Biomedical Science lecturer repeatedly asked their students to do so.

Notes were taken by the researcher throughout on any key messages students shared or important observations made.

To combat the possibility of students leaving early, the online groups were kept small (with a maximum of five students), with the author also memorising the name of each participant and directly calling upon each one by name during the intervention. This was successful in preventing students from leaving early. Referring to the students directly meant students knew they would be recognised as missing if they left. This was not a problem with face-to-face delivery.

A lesson plan was also used by the researcher to ensure all students had a similar experience with the intervention, which can be found in Appendix 6.

6.3 Results

Only students who had completed both the pre- and post-intervention questionnaire were considered when analysing their results. Descriptive statistics for the pre-MA score and post-MA score can be found in Table 6.2.

Table 6.2

Descriptive statistics of pre-MA and post-MA scores

MA Score	Sample	Mean	Median	Minimum	Maximum
MA score (pre)	21	3.26	3.20	1.80	4.90
MA score (post)	21	3.33	3.50	1.90	4.60

A score of 5 is the highest possible MA score. Therefore, overall, students appeared to be slightly more mathematically anxious after the intervention. However, as noted before, several students appeared to complete the post-intervention questionnaire around the time of coursework/exam deadlines. This may have skewed the results since the scale does include questions pertaining to mathematics tests. The intervention itself and the pre-questionnaire were usually delivered away from exam periods for this reason. Two students missed out on answering one of the scale questions in the MA questionnaire: one student did so on the pre-MA questionnaire whilst another did so for the post-MA questionnaire. Average responses were calculated for these two students based on their other responses to the MA questionnaire, but there is the possibility that these calculated averages were not how the students themselves would have responded to those questions. One student completed the pre-MAMR questionnaire before and after the intervention so for their pre-score, the first questionnaire results was considered.

The descriptive statistics for the pre and post-MR scores can be found in Table 6.3.

Table 6.3

Descriptive statistics of pre-MR and post-MR scores

MR score	Sample	Mean	Median	Minimum	Maximum
MR score (pre)	21	4.07	4.13	3.04	4.70
MR score (post)	21	4.06	4.13	3.30	4.96

A score of 5 is the highest possible MR score. The points mentioned above are also applicable here, though it is worth noting that both the minimum and maximum MR score increased for students. However, the mean MR score did decrease marginally.

A Shapiro-Wilk test was conducted on the data, which returned non-significant results, and as such, a paired sample t-test was run to determine whether the difference in mean score from the pre-intervention and post-intervention questionnaires was significant. On average, it was found that students were slightly more mathematics anxious after the intervention (M=3.33, SD=.874) than before (M=3.26, SD=1.00). This increase in MA, 0.07, was not statistically significant, t (20) = -.737, p=.470.

The same test was used to analyse whether the change in MR score was statistically significant. Students were slightly less mathematically resilient after the intervention (M=4.06, SD=.440) than before (M=4.07, SD=.435), but again, this decrease in MR, 0.01, was not statistically significant as expected, t (20) =.471, p=.943.

To understand these results further and on an individual basis, a comparison of the MA and MR scores of all 21 students can be found in Table 6.4.

Table 6.4

Individual MA and MR scores of 21 participants

Student	preMA	postMA	MA change	MA change	preMR	postMR	MR change	MR change	Delivery form	Intervention date	Post response	Visited
1	3.8	4.1	0.3	Increase	4.35	4.26	-0.09	Decrease	Online	15/02/2021	20/03/2021	YES
2	2.9	3	0.1	Increase	4.22	3.83	-0.39	Decrease	Online	15/02/2021	29/04/2021	YES
3	1.9	1.9	0	No change	4.7	4.22	-0.48	Decrease	Online	22/03/2021	07/05/2021	YES
4	4.4	4.1	-0.3	Decrease	3.74	4.43	0.69	Increase	Online	25/11/2021	16/01/2022	NO
5	4.9	4.6	-0.3	Decrease	3.04	3.87	0.83	Increase	F2F	13/10/2021	10/02/2022	NO
6	2.1	2.2	0.1	Increase	4.43	4.30	-0.13	Decrease	F2F	13/10/2021	10/02/2022	YES
7	1.9	2	0.1	Increase	4.09	4.13	0.04	Increase	F2F	13/10/2021	10/02/2022	NO
8	2.9	3.2	0.3	Increase	4.26	4.39	0.13	Increase	F2F	07/10/2021	10/02/2022	YES
9	2.1	2.3	0.2	Increase	3.61	3.96	0.35	Increase	F2F	13/10/2021	13/02/2022	NO
10	3.9	3.8	-0.1	Decrease	4.13	3.61	-0.52	Decrease	Online	10/02/2022	15/02/2022	YES
11	3.2	3.6	0.4	Increase	3.78	3.30	-0.48	Decrease	F2F	13/10/2021	17/02/2022	NO
12	3.4	3.8	0.4	Increase	4.35	4.96	0.61	Increase	Online	14/02/2022	19/02/2022	NO
13	1.8	2.1	0.3	Increase	4.57	3.39	-1.18	Decrease	Online	09/03/2022	10/03/2022	NO

14	3.6	3.4	-0.2	Decrease	3.83	3.96	0.13	Increase	F2F	07/10/2021	06/04/2022	NO
15	4.1	3.8	-0.3	Decrease	3.96	4.17	0.21	Increase	F2F	07/10/2021	06/04/2022	YES
16	3.1	4.5	1.4	Increase	3.52	3.65	0.13	Increase	F2F	07/10/2021	06/04/2022	NO
17	2.6	2.6	0	No change	4.57	4.61	0.04	Increase	F2F	07/10/2021	06/04/2022	NO
18	2.4	2.9	0.5	Increase	4	3.87	-0.13	Decrease	F2F	07/10/2021	08/04/2022	YES
19	4.7	4	-0.7	Decrease	3.48	3.43	-0.05	Decrease	Online	10/02/2022	05/05/2022	YES
20	4.1	3.5	-0.6	Decrease	4.65	4.70	0.05	Increase	Online	10/02/2022	05/05/2022	YES
21	4.6	4.5	-0.1	Decrease	4.13	4.22	0.09	Increase	Online	10/02/2022	09/05/2022	YES

It can be seen that two students had no change in their MA score, with both having relatively non-existent levels of MA (less than 3, meaning they had answered completely disagree or disagree to most of the questions). For those students that had an increase in their MA, several had completed the post-intervention questionnaire around their coursework/exam period (which is classed as March onwards in this research). It can also be seen that the six highly anxious students (pre-MA scores of over 4) all showed a decrease in MA, perhaps indicating that the intervention is more useful to the more anxious students. In the case of student 16, who showed a considerable increase (1.4) in MA, some more context may provide some clarity on the situation. The student was part of a first-year cohort that received the intervention at the start of their academic journey. This would have been before any mathematics was taught on the course. They then completed the post-intervention questionnaire in exam season. As students progress through their course and prepare for exams, their MA continues to rise (Yurtcu & Dogan, 2015), and this could explain some of the increase in student 16's anxiety.

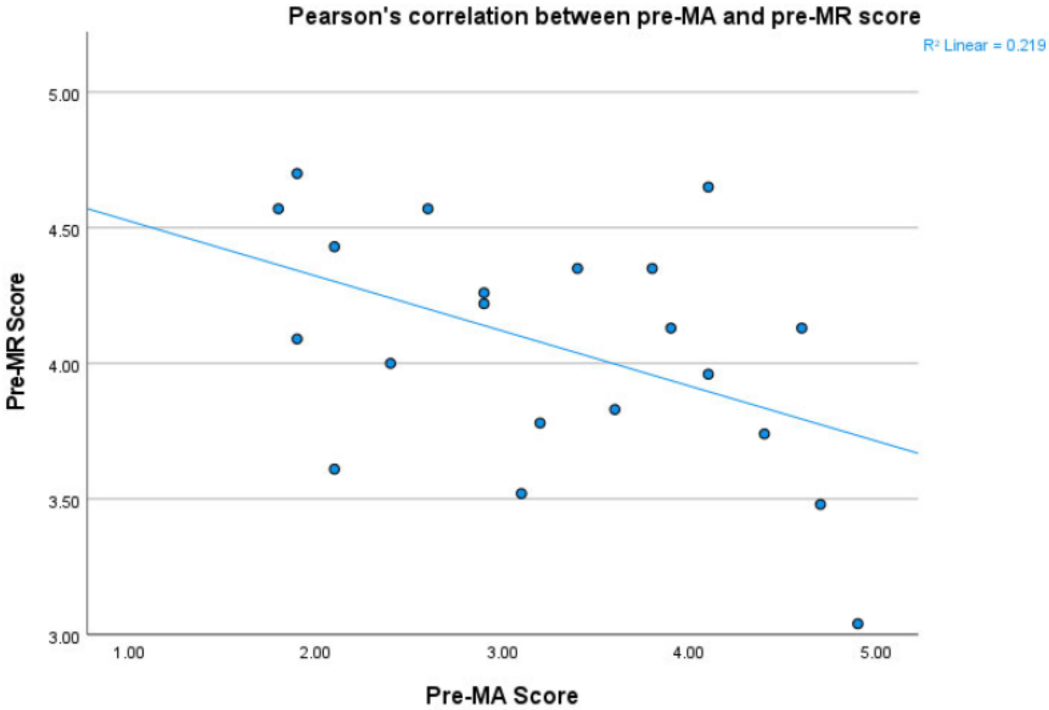
When looking at the resilience scores, a positive result is that Participant 5, who had a pre-MA score of 4.9 out of a possible 5, had a reduction in their MA, although they were still highly anxious with a score of 4.6. However, their MR increased markedly by 0.83, though it cannot be said whether this change was significant. Though there appears to be an overall decrease in most students' MR courses, these were not large drops; the small differences in the mean scores presented here is accounted for by the natural variability of the data since the statistical analysis conducted did not return a significant result.

6.3.1 Correlational analysis

A Pearson correlation coefficient was computed to assess the relationship between the pre-MA and pre-MR score of students since both were scale variables. It was found that there was a significant moderate negative correlation found between the two variables, $r(20) = -.468$, $p = .032$. A graph to display this is seen in Figure 6.3. For clarity of the relationship, the axes do not start at the origin as you cannot get a score of zero for either scale.

Figure 6.3

Pearson's correlation between pre-MR and MA score



The trend can clearly be seen that as students increase in MR score, their MA score decreases. It is the students that have low scores of MR and high scores of MA that would be of most concern, since this would mean they were not resilient but also very anxious, but as seen in Chapter 5, these students did tend to avail of the support.

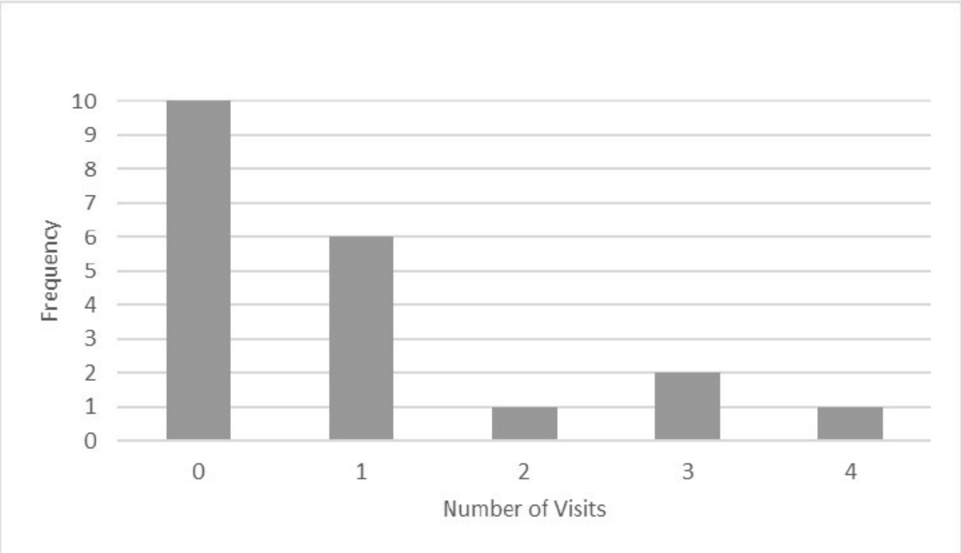
It is interesting to note that when a Pearson's correlation was run to calculate the relationship between post-MA and post-MR score, there was no significant correlation found between the variables, with r(20)=-.040, p=.862. After the intervention, it seems as though students' resilience levels were perhaps not related to MA score, but an external factor, and the same could be said for a student's MA score. Due to the time when several participants completed their post questionnaires, it could be that their MA score was now related more to their levels of test anxiety and how prepared they felt for their exams.

6.3.2 Model

To account for the various confounding factors when looking at the effect of the pre- and post-MA and MR scores on engagement with MSS, a Poisson model was used with an offset and two adjustment terms. Adjustment terms are a means of controlling confounding factors, which, in this model, are the different courses students were on and the years in which they visited. This is because students from courses such as the biosciences were more likely to visit in their first year, for example, whilst Psychology students were more likely to visit in their third year. If a students' pre and post intervention visits to **sigma** were in the academic year students from their course tended to engage in, an adjustment was necessary, but if their pre- or post-visits were not in this year, no adjustment term was added. The offset term on the other hand considered the different unequal observation intervals, i.e., the different lengths of time participants had to visit **sigma** before and after the intervention. As the student that visited 14 times is clearly an outlier, they have been removed from the analysis to ensure a better-fitting model.

Figure 6.4

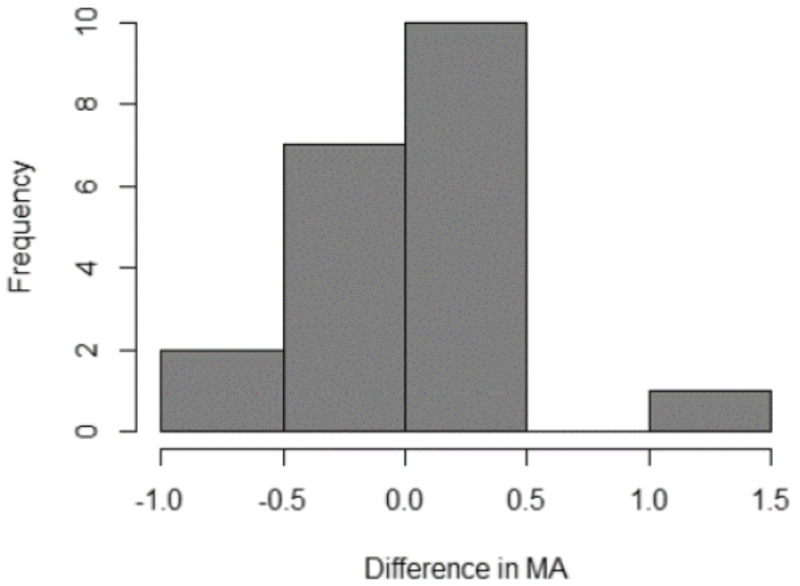
Frequency of post-visits made to sigma truncated at 4 visits



The original model contained post visits as the dependent variable, whilst post-MA score, post-MR score, the offset term, and the two adjustment terms were predictor variables. However, none of these predictor variables were returned to be significant even when each was removed from the model in turn. Consideration was therefore given as to whether the difference in MA score from before the intervention to after the intervention had some bearing on the number of post visits. The changes in MA are summarised in Figure 6.5.

Figure 6.5

Frequency of the changes in MA scores by intervention participants



A model with post visits as the dependent variable was examined with Difference in MA and the first adjustment term as predictor variables. "Difference in MA" represented the change in students' MA scores from before the intervention to after the intervention, with a positive score indicating there was an increase in their MA. "ADJ1" accounted for the year that students from each course typically engaged in: if students engaged in Year 3, but the data gathered from these students only covered the first two years of their academic journey, ADJ1 would be zero, for example. An interaction term was also included between these predictor variables to examine whether the effect of a difference in MA was the same irrespective of whether post visits occurred in the regular academic year that students from that course usually attend in. The results summarised in Table 6.4 show that both predictors and their interaction are statistically significant.

Table 6.5

Poisson model with variables predicting visits made to ***sigma***

Variable	β	p-value
Difference in MA	-2.114	.019
ADJ1	1.433	.005
ADJ1: Difference in MA	6.724	<.001

The interaction term 'ADJ1: Difference in MA' being significant ($p<0.001$) does indeed provide strong evidence that the effect of a difference in MA on post visits is different, depending on whether those visits occurred in the regular academic year that students from that course usually attend in.

MA and MR being non-significant showed that these scores did not affect visits. For MR, this was expected since it is what was seen in Chapter 5; however, it was somewhat surprising that MA did not since, in Chapter 5, MA was a significant predictor of engagement. This may be due to the differences in sample size or the effect of the intervention.

Therefore, considering the intercept was 0.71, Table 6.4 can be explained as a model in the following terms:

$$\log(mean\ post\ visits) = -0.71 - 2.11 * Difference\ in\ MA + 1.43 * ADJ1 + 6.72 * Difference\ in\ MA * ADJ1$$

Hence for students *not* visiting in the academic year that students from that course usually attend in (ADJ1=0):

$$\log(mean\ post\ visits) = (-0.71 - 2.11) * Difference\ in\ MA$$

This indicates that for these students the effect of a 0.1-point increase in their MA is associated with a reduction in log (mean visits) by -2.11*0.1 = -0.211, or equivalently is associated with mean visits being multiplied by $e^{(-0.211)}$ or 0.81, indicating a reduction in visits by 19%.

For students visiting in the academic year that students from that course usually attend in (ADJ1=1):

$$\log(mean\ visits) = -0.71 - 2.11 * Difference\ in\ MA + 1.43 + 6.724 * Difference\ in\ MA$$

$$= (-0.71 + 1.43) + (-2.11 + 6.72) * Difference\ in\ MA$$
$$= 0.71 + 4.61 * Difference\ in\ MA$$

Which indicates that for these students the effect of a 0.1-point increase in the MA is associated with an increase in log (mean visits) by +4.61*0.1=0.461, or equivalently, is associated with mean visits being multiplied by $e^{0.461}$ or 1.59, indicating an increase in visits by 59%.

Thus an increase in students' MA is associated with 19% fewer visits in the academic years their course does *not* usually attend in, but a much larger increase in visits by 59% in the academic years their course does usually attend in.

This model suggests that irrespective of the intervention itself, an *increase* in the change of MA by 1 integer indicates an increase in log (visits) by 4.61. Therefore, if there is an increase in MA by 0.1 for students that visit in the academic year that their course usually attend in, there is an increase in log (visits) by .461, which is a multiplicative increase of 1.59. Therefore, mean visits would increase by 59%. This supports what is usually seen in **sigma**, where there is an increase in student visits around assessment periods, with assessments most probably causing an increase in students' MA score. In the previous chapter, it was found MA and visits are related, with an increase in MA predicting an increase in engagement. This analysis shows a slightly different result, and that it perhaps is not only the level of MA that influences their engagement with MSS, but also, an increase in an individual's MA score may encourage engagement. For example, if a student is not mathematically anxious at the start of their course, but becomes more MA over the academic year their course usually engages in, then they may be more likely to visit as opposed to a student who has the same level of MA throughout the academic year. Participant 4 for example, had been anxious from the start of their course and did not engage with **sigma** around exam time despite students in Computer Science usually engaging in first year (ADJ1). However, these students had all been made aware of **sigma** during the intervention to address comments made in the literature about structural reasons influencing students' non-engagement (O'Sullivan et al., 2014). Therefore, a change in students' MA is not enough to encourage engagement; they must also be given the tools to seek support, such as the tools provided by the intervention in the case of this study.

To explain the relationship when ADJ=0, consider a Psychology student. Psychology students usually engage in with **sigma** in their third-year. When students are not in their third-year (ADJ1=0), students may not feel supported or may not have adequate knowledge of **sigma** since for Psychology students in particular, they learn more about **sigma** from their third-year project supervisors. They may not see the value of mathematics in their first two-years since they cannot see the application of it just yet, meaning they have lower levels of MR (particularly on the value scale) than they perhaps do in their third-year. Therefore, despite them having some increase in their MA, they cannot yet see the importance of mathematics to their course. When they move from the growth zone to the anxiety zone, they do not have the resilience to move out of the anxiety zone, which leads to a significant decrease in their visits.

However, for a Psychology student in the third-year (ADJ1=1), arguably their most important year mathematically because of the statistical content needed in their projects, moving into the anxiety zone prompts a different response. They are able to see the value of the mathematics they need to know helping them move out of the anxiety zone (and back into the growth zone), and the fear of failure also may override any associated fears with engaging, as was shown in Chapter 8. This leads to an increase in visits to **sigma**. Therefore, it is of paramount importance that all students, just as they were in the intervention, are taught about how to use the support, the benefits of the support, and its non-judgemental nature.

When the same analysis was run with MR and change in MR score as factors, neither were returned as significant predictors.

6.3.3 Student feedback

Results in this section generally discuss the responses of the 22 students that completed the post-intervention questionnaire.

On the post-intervention questionnaire, student feedback was gathered through a series of questions, which can be found in Appendix 9. It was positive to note that months after the intervention, students could still recall the content of the intervention since when they were asked what strategies they would continue to use, they were able to reference specific models shared in the intervention.

Further to this, eight students said they were more likely to use **sigma** because they were more aware of the services offered and because the intervention helped them overcome some of the anxiety they had around mathematics and seeking help. Two students responded that the intervention had helped them overcome some of the anxiety that they have around mathematics and seeking help.

The first feedback-related question students were asked was:

"What, if anything, have you learnt from the intervention about how to approach the maths in your course?"

Table 6.6

Common themes in responses to, "What, if anything, have you learnt from the intervention about how to approach the maths in your course?"

Categories	Illustrative quote	Number of responses
Soothing anxiety	*"It also gave me some ideas for good ways to deal with being calm when approaching maths, and a better mind set etc."*	11
Asking for help	*"There is always help available when I am struggling with maths"*	7
Resilience – struggle	*"I learned that its normal to have struggles with stuff like this and it is way more common that I thought"*	5

As expected, most responses focused around building their resilience and managing MA. Interestingly, from the dimensions of MR, struggle appeared to be mentioned the most, particularly that students could now acknowledge they were not alone in their struggle.

"I learned that it's normal to have struggles with stuff like this and it is way more common tha[n] I thought."

Being able to access help for their mathematical concerns and knowing of the availability of support was also raised.

"I learnt that I should try to answer the questions however support is there if I need it."

The core theme that arose from responses was students feeling better equipped to deal with their MA and some students even mentioned specific techniques for doing so.

"It also gave me some ideas for good ways to deal with being calm when approaching maths, and a better mind set etc."

Students were then asked:

"What did you find most helpful about the intervention?"

Table 6.7

Common themes in response to, "What did you find most useful about the intervention?"

Categories	Illustrative quote	Number of responses
Reducing MA	*"The tips to overcome the anxiety was the most helpful part of the intervention."*	6
Methods taught	*"Learning how to recognise the points where you should stop and put the problem down then return to once you fall back within a learning zone."*	5
Seeking help	*"I knew barely anything about sigma beforehand, but I feel I could go to them for help now."*	3

Again, understanding that struggle is a normal part of learning mathematics and other courses seemed to resonate with students. In particular, many students found that discussing their struggles with mathematics with their peers was the most useful aspect of the intervention.

"Talking it through with others who also experience maths anxiety and the advice given to help combat same."

Knowing that support is available and learning about **sigma** was also mentioned. Although the students were on courses that involved mathematics/statistics, it appeared as though there was little knowledge on what **sigma** was. However, lecturers did say that **sigma** had been mentioned to students. Perhaps this reinforces the idea that students need to be told repeatedly and in more detail about the support for the information to be retained.

"I knew barely anything about ***sigma*** *beforehand, but I feel I could go to them for help now.*"

Students also mentioned aspects of the models discussed as being especially useful.

"The explanation of how the brain works when uptight."

"Learning how to recognise the points where you should stop and put the problem down then return to once you fall back within a learning zone."

The third feedback question was:

"What could be improved about the intervention?"

Table 6.8

Common themes in response to, "What could be improved about the intervention?"

Categories	Illustrative quote	Number of responses
More sessions or content	*"More discussion time"*	**9**
Nothing	*"Nothing - really useful"*	**6**

The main two responses received was that nothing could be improved (*"the intervention was really good, I felt it was delivered in a way that people could easily understand and easy to follow. I don't feel that any improvements were needed to it"),* or that there could be more sessions/more content. This may be because some students had the content condensed into a one-hour session. Students also made suggestions for the type of content they wanted more of, such as more time for discussion with their peers or team activities/examples.

"Maybe add group exercises involving solving maths problems and see how we implement each of the different techniques mentioned and new ones we come up with."

The final question asked was:

"Which methods did you learn about that you will continue to use?"

Table 6.9

Common themes in response to, "Which methods did you learn that you will continue to use?"

Categories	Illustrative quote	Number of responses
Reducing MA	*"Methods to calm myself down if I'm feeling frustrated about maths problems."*	*12*
Models	*"Visualise the brain function when relaxed and when uptight."*	*4*

There were not many common responses to this question; students had different key methods and models that resonated with them. One response was particularly enlightening.

"The methods aren't too important to me. It is more important for me to know that I am not the only person with Maths and test anxiety."

This shows how essential it is to open a conversation amongst the group about MA when delivering the intervention. This was mentioned multiple times throughout the feedback question responses.

6.3.4 Engagement with MSS

Twelve students out of 22 (54.5%) did engage with the **sigma** drop-in service after the intervention (some repeatedly), and 10 did not. Only four of these 12 students had engaged with MSS previously, one of whom had discussed with the researcher before the delivery of the intervention their difficulties with mathematics and asked in what ways MSS staff could support them, with another student having heard of the support when the intervention was advertised to them during lecture time.

Two additional students who had participated in the intervention but not completed the post-intervention questionnaire also engaged with MSS after the intervention. There is a stark contrast between the engagement with MSS of those that completed the post-questionnaire and those that did not, perhaps indicating a relationship between their amenability and their likelihood of engaging with MSS services or perhaps just that those who completed the post-intervention questionnaire were more engaged overall. It may also be that the students that did not complete the post-questionnaire were less MA and as such, did not find the intervention as useful (with most non-respondents being from an Analytical Chemistry cohort).

Nineteen out of 22 students (86%) said that the intervention made them more likely to use MSS services. One student said they responded "no" only because they were not yet in the quantitative part of their study, whilst another said they were instead more likely to engage because, "*I now know that the tutors were in the same position like me once where they needed help and support and they won't think my questions are stupid*". This illustrates the importance of MSS staff being seen as knowledgeable but also approachable and can also struggle with mathematics like everyone else. It seems as though students feel there is an insurmountable gap of knowledge between what they know and what the staff members know, and it is imperative they are disabused of this notion so that they are able to seek support when needed.

6.3.5 Impact of staff attitudes towards mathematics

One of the prominent difficulties of the practicality of the intervention was establishing relationships with faculty staff so they would allow advertisement of the intervention within regular student contact hours. Some staff members were supportive of this, whilst others understandably spoke of the time constraints they faced in relation to delivering all of their course content. However, at least one member of staff approached for the intervention did not see it as relevant for their students, despite their students being highly MA. Although some lecturers did not co-operate, some of their students did seek help with their MA, and one of these students actually changed course because of fear of the mathematical content. This may be a contributing factor to the increase in students' MA. Anxiety may be increased firstly by those in authority not acknowledging that it is a problem that needs to be addressed and, secondly, that it is not normal and acceptable to seek support.

Further to this, other staff members were in fact interested in running this study with some of their peers too as they believed MA levels were high amongst academic staff in several departments. They also acknowledged that there was a general fear in several departments that staff were not allowed to acknowledge any of their difficulties with mathematics. It appears as though there is a stigma around staff members seeking support with what they regard as basic topics. Staff feeling unable to seek support for their own difficulties with mathematics may influence how students feel about mathematics and seeking support too, as struggling with mathematics can generally relate to lower confidence in mathematics. As the aim of this research is to seek understanding on student engagement with MSS, not staff engagement, the author acknowledged and recognised the importance and impact of low mathematical confidence in staff and lack of help-seeking on student engagement, too. Therefore, the staff were advised to seek support as MSS is available for everyone, students and staff alike, and it is essential that staff are comfortable with delivering and learning mathematics. They were also told that this feeling is not isolated to them and many staff members across universities worldwide are potentially sharing the same thoughts. This appeared to have some positive effects as these staff members then went on to share this with their students.

The staff being mathematically anxious and less confident with mathematics may be having an impact on the psyche of students and their MA levels, which is supported by Lau et al. (2021), who found, from a sample of 1175515 individuals, that students' opinions about their mathematics teacher's competence was positively correlated with lowered MA scores. If staff develop and foster an atmosphere that aids in building their own and their students' MR levels to reduce MA, this could be of some benefit such as where the lecturer was present during the face-to-face sessions and shared their own history with mathematics. Therefore, allowing staff members to also participate in the intervention would be of benefit. However, despite the lecturer being present during the face-to-face sessions in this study since they were held during regular lecture hours, in future deliveries, it may be best to hold separate sessions for lecturers to participate in for the comfort of both lecturer and student. Lecturers could be asked to perhaps share with the students their relationship with MA to reinforce that MA is not associated with being unsuccessful or stupid.

It must be highlighted here that this section is primarily informed speculation and there has been no measurement of staff MA and MR. Further studies are necessary to determine if any evidence exists to either support or reject the hypotheses mentioned in this section.

6.3.6 Key points from researcher notes

Key observations made by the researcher throughout the intervention sessions and correspondence with students are highlighted here.

6.3.6.1 Difference between online and face-to-face delivery

The difference in the mode of delivery had some apparent effect on the comfort of the students with participating, which the researcher noted down.

The researcher observed that in larger groups students seemed to feel more uncertain about sharing their prior traumatic experiences with mathematics; there was greater hesitancy in answering questions in larger groups as expected. It was also apparent that they were more comfortable with sharing when they did not know the other students in the intervention group perhaps due to the safety that this degree of anonymity brings. Therefore, students appeared to be more comfortable with online delivery, since these sessions were smaller groups of students who did not know one another. However, once the author, the lecturer or a student opened-up about their experiences during face-to-face delivery, other students followed swiftly. This may be because they realised they were not alone in their feelings about mathematics and there was relatability with others in the group, which is an aspect of MR. Having the intervention online also meant that students who were studying completely online or who were distance-learners were able to participate.

Descriptive statistics were used to identify if there appeared to be a visible difference in the change of MA and MR based on the form of delivery, which can be seen below.

Table 6.10

Descriptive statistics of pre-MA and post-MA scores for face-to-face delivery

Face-to-face	Sample	Mean	Median	SD	Minimum	Maximum
MA score (pre)	11	2.99	2.90	.927	1.90	4.90
MA score (post)	11	3.19	3.20	.889	2.00	4.60

Table 6.11

Descriptive statistics of pre-MA and post-MA scores for online delivery

Online	Sample	Mean	Median	SD	Minimum	Maximum
MA score (pre)	10	3.55	3.85	1.05	1.80	4.70
MA score (post)	10	3.48	3.80	.877	1.90	4.50

The online group were more anxious overall, reporting a higher mean and median MA score. Since the face-to-face intervention was conducted with whole cohorts, whilst the online students were usually those that had personally opted in for the intervention, this is perhaps as expected. Their post-MA score was also higher on both counts, although the maximum score changed from 4.7 to 4.5. The online students were slightly less anxious (-.07) after the intervention when comparing their pre and post mean and median scores, as opposed to those that had the face-to-face intervention, who showed an increase in their MA (+.20), perhaps signalling that delivering such interventions and support online for anxious students may be of more benefit than in-person support, although the sample size of the two groups suggests that we should be cautious in drawing such a conclusion.

The descriptive statistics of the MR scores amongst the two different forms of delivery was also checked.

Table 6.12

Descriptive statistics of pre-MR and post-MR scores for face-to-face delivery

Face-to-face	Sample	Mean	Median	SD	Minimum	Maximum
MR score (pre)	11	3.92	3.96	.435	3.04	4.57
MR score (post)	11	4.02	3.96	.361	3.30	4.61

Table 6.13

Descriptive statistics of pre-MR and post-MR scores for online delivery

Online	Sample	Mean	Median	SD	Minimum	Maximum
MR score (pre)	10	4.23	4.28	.389	3.48	4.70
MR score (post)	10	4.11	4.22	.530	3.39	4.96

The pre-MR scores of the online group were higher than those in the face-to-face groups, which again, may seem obvious since these students generally opted in for the intervention by emailing the researcher of their own accord, whereas the face-to-face students were introduced to the intervention during regular lecture contact hours. Whilst the mean and median score for MR across the online group decreased, the variability in the data increased. However, the mean and median MR score for the face-to-face group showed a positive change and no change respectively. Students in the face-to-face group also received the intervention either at the start of their first or second academic year, showing their MR score slightly increased as the year progressed (potentially because they began to see the value of mathematics), but as seen previously, the MA score also increased.

A paired samples t-test was conducted to measure whether this difference in mean was significant between the online pre and post results, and the face-to-face pre and post results.

Table 6.14

Paired sample t-test results showing whether a significant difference exists in the pre and post-MA and MR results between online students

Online	t-statistic	p-value
Pre and post-MR	.726	.486
Pre and post-MA	.591	.569

Table 6.15

Paired sample t-test results showing whether a significant difference exists in the pre and post-MA and MR results between face-to-face students

Face-to-face	t-statistic	p-value
Pre and post-MR	-1.037	.324
Pre and post-MA	-1.383	.197

These tables show that the differences seen in the MA and MR scores when the participants were split into their face-to-face and online groups were not significant.

6.3.6.2 Student comments during the intervention

During the intervention, students shared experiences of when they recalled beginning to feel negatively about mathematics, with many referring to tales about their teachers or parents from as young as primary age. Another contributor to MA was also the reaction of their peers. One student, when it was realised they were not paying attention, was asked to solve a mathematics question on the whiteboard in front of their class, and they did not know the answer. They became known as the "stupid" student. Similar stories were shared by many of the participants. It was evident that being publicly humiliated during mathematics lessons has been a reason for the increase in many students' MA levels.

Another interesting point raised by students was that students' reaction to the anxiety (red) zone could look differently to students at different times. When students were asked to reflect on how they felt when they were in the red zone, they highlighted that it was not necessarily "one-size-fits-all". Sometimes they reacted by becoming quiet and their conflict was internal, whereas at other times, they became visibly frustrated. For this reason, when students in the later interventions were asked to reflect on their emotions during each of the learning zones, this was emphasised, particularly that students needed to become adept at identifying when they were in the red zone, irrespective of the way it presented itself. Negative emotions were indicative of a student not being in the growth zone.

Many students also indicated that being introduced to the concepts of MA and MR at the start of their course would have been hugely beneficial. It was reiterated throughout sessions that students were surprised to hear the researcher and other **sigma** staff also sometimes did not know answers to mathematical questions, and the sentiment was repeated when, in the face-to-face sessions, lecturers also confirmed the same about themselves.

One student (Participant 4) had an especially high MA score and therefore, the delivery of the intervention took more contact hours. They attended the intervention sessions alone. The participant also continued to message the researcher to update them on their progress with the mathematics on their course, their anxiety and seeking help with **sigma**. Further details are shared in the subsequent section (6.3.6.3) about the impact of the intervention on this individual participant and how MA and MR affected their studies and engagement with MSS.

6.3.6.3 Participant 4

Participant 4 was a Computer Science student who had a very high MA score (4.4). This student volunteered for the intervention via email.

Participant 4 had not attended lectures at all because they were so concerned about being asked questions and struggled with the online format and speed of delivery. They contacted the researcher via email having seen on their Aula page that the researcher had attended a lecture to explain MA and MR. Within the email, they discussed their lack of confidence in mathematics and had only previously studied a BTEC[1] in Information Technology. They also highlighted that since the pandemic had hit in the previous year, they were anxious about being in lectures, not because of a concern of falling sick, but because they were no longer accustomed to it and did not feel like they belonged in an academic setting. Whether this was because it had been some time since they had been in a physical classroom, or because of their lack of confidence in their own ability to do mathematics, was unclear. Although it was not directly asked whether Participant 4 only felt this way about mathematics lectures, in their initial email to the researcher, they specified that their anxiety was about their mathematics module and they did not attend their mathematics lessons.

[1] A Business and Technology Education Council is a vocational qualification that focuses on developing skills for work. A level 3 BTEC is seen as an alternative to A levels.

Although the typical length of the intervention for a single student was an hour, more time was needed with this student due to the trauma they had experienced around mathematics. The intervention was delivered as a one-to-one session over Microsoft Teams. The student continuously got derailed from the models shared in the intervention because of the negative thoughts they associated with mathematics. They asked for reassurance multiple times that provided they started to engage with the mathematics on their course, they would still be able to pass the year. After the intervention, they did appear to be more mathematically resilient (3.74 and 4.43 respectively) and less MA (4.4 and 4.1 respectively).

Not only had this student not attended any lectures, but they also had not been engaging with the coursework they were assigned because of difficulties with the material. There was a real fear this student would fail their course. The author contacted the lecturer to make them aware of the situation with the permission of Participant 4, who then deferred the student's exams to the following semester and provided course support.

The student shortly shared that they had begun to engage with lectures after the intervention and had begun to make a concerted effort to succeed with their course. Participant 4 messaged **sigma** several times to seek their support and had even organised times to meet with certain staff members. However, they never used the support and missed the time slots they had booked. There was clearly an avoidance of the support even after booking appointments because of fear. Again, they needed reassurance that the staff would be able to help them as they needed and that they would not be judged for their lack of knowledge on the mathematics in their course. This was all shared with the researcher over Microsoft Teams.

They succeeded in being agentic in their learning, which is a facet of MR and engagement, through seeking resources online and by reading relevant books and have managed to pass most of their modules. The student did believe the intervention was very useful to them and had encouraged them to persevere in their learning despite their MA.

6.4 Discussion

The intervention used in this thesis was adapted from materials in prior research into MA and MR (Baker, 2021; Johnston-Wilder et al., 2020; Johnston-Wilder et al., 2018), though it had not previously been used as a means of also increasing engagement with MSS. Instead, these methods were previously used to reduce the MA students face so they may be successful in their mathematical learning. Small studies have shown that the intervention has been successful to this effect, but these studies have focused mostly on schoolchildren (for example, Chisholm, 2017; Johnston-Wilder et al., 2015) with feedback from these studies generally being qualitative. Cousins et al. (2019) explored the change in belief about mathematics in four adult learners through increasing their MR and most notably for this research, sensitive support from loved ones, with students managing to become more comfortable in persevering with mathematics. Highlighting **sigma** staff as being approachable and by using **sigma** staff to develop the intervention is one such way students can find this support in their learning.

The changes made to the intervention were mostly due to the change in the form of delivery, and to add detail around the benefits of **sigma** in supporting these students. The onset of the pandemic forced the delivery of the intervention to primarily be online for the comfort and safety of both the researchers and students, but three sessions were able to be held in-person during regular lecture contact hours at the beginning of the 2021/22 academic year. Group sizes also differed widely, with the face-to-face classes having more than ten students in a single session, whilst the online sessions were held with between one to four participants. This variation in delivery increased the scope of findings as it was able to be determined what might be the best form of delivery for such an intervention.

Quantitative analysis of the pre and post intervention questionnaire did not provide many clear answers as to the success of the intervention, perhaps because the intervention was delivered usually at the beginning of the academic year, when there was more availability, whereas students answered the post-intervention questionnaire in their own time. This resulted in several students completing the questionnaire during their exam period, which may have skewed the results. Whilst the results showed an increase in MA and a decrease in MR overall, neither change was significant, including when students were divided into groups according to the form of delivery, meaning the difference could be explained by random variation.

When considering engagement with MSS, 54.5% of respondents to the post-intervention questionnaire students engaged with **sigma** (8/13 of which were online students) whilst 86% extolled the benefits of the intervention in explicitly encouraging that engagement and also helping students to feel better equipped to handle their MA. This provided some evidence that it was the intervention, and not other extraneous factors such as course of study (which was shown to be a significant predictor of engagement in Chapters 4 and 5), that aided them in seeking engagement.

The only group to show a decrease in their MA score were the online students, though again this decrease was negligible. The online group of students had higher pre-intervention MA scores, perhaps suggesting both the intervention and MSS being delivered online may be more beneficial for more anxious students. Most of these students did have the option of receiving the intervention face-to-face, and so it is somewhat telling that they opted for the online support instead, the form of delivery that they might see as providing them with a greater sense of anonymity and security, with Hodds (2020a) finding that anxious students may prefer online support to face to face support for this reason. This is further supported by qualitative findings that will be discussed in Chapters 7 and 8, and from Chapter 5, which found MA score predicted engagement when MSS provision was predominantly online.

The Poisson analysis provided more insight into the relationship between MA and student engagement than the correlations in this chapter. Neither MA nor MR were significant predictors of engagement after the intervention, indicating that another variable may in fact have influenced engagement. Further analysis revealed a key finding: an increase in levels of MA predicts engagement; this may be because as a student "increases" their growth zone and leaves their comfort zone, they may enter the anxiety zone, which is where **sigma** can help with helping students back into the growth zone (Lee & Johnston-Wilder, 2018). It also suggests that whilst students find the intervention encouraged their engagement, this may be because the intervention helped students build familiarity with MSS staff and advertised the availability of the centre to them.

Furthermore, as the academic year progresses, more students do avail of the centre, and this may indeed be because students start finding the mathematics in their course more difficult. It is also common for students to ask for help with what appears to be a more "complex" branch of mathematics, and it is only after some discussion with the staff that it is realised that help is actually needed on the mathematics that underpins the topic, such as needing to understand percentages to be able to work out drug calculations. This suggests that it is when students realise they are struggling with mathematics, and perhaps have the pressure of examinations or assessments too (which contributes to their MA score increasing), that encourages engagement. Considering that there was no control group to measure the effect of the intervention itself on engagement, it cannot be determined whether the intervention itself increased engagement except through what students commented on feedback forms. However, it did make all the students aware of the support, which previously was claimed to be why some students did not engage (O'Sullivan et al., 2014). Considering the small sample size, and this novel finding on the change in MA affecting visits, more work must be undertaken to determine the meaning of this result.

Qualitative analysis displayed another perspective on the intervention with students alluding to its use and benefits, months after they had first been presented with the intervention, which is reinforced by what has been found in Cousins et al. (2019); Chisholm (2017) in primarily face-to-face deliveries of the intervention. However, it was also noted that whilst students could recall the contents of the intervention, this may have been because of the high involvement of the bioscience lecturer, with the research, with most of the intervention consisting of bioscience students. Having embedded MA interventions, with the lecturer reinforcing the information from the intervention particularly around exam time, may therefore be of more use to students.

The adaptability of the intervention meant it was easy to accommodate for the different time requirements of both the staff members and students involved. In particular, students that attended the intervention online appeared to have multiple time constraints such as caring responsibilities, and thus, should the intervention be used in such a way in future, the option of online delivery should always be made available to students.

It also appeared that staff can impact a student's confidence in mathematics and both their MA and MR scores, though more work must be conducted to check this assumption. Beilock et al. (2010) reported how the higher a teacher's MA, the more likely it was that female students (in primary school) had lower achievement in mathematics and the more common it was for them to support gender stereotypes on the mathematical ability of women. When staff were clear with students about their own relationship with MA, where it existed, this allowed the students to be more open about their own feelings as they felt they were less likely to be seen as stupid by both the staff and their peers. Both the researcher and staff were therefore reinforcing the fact that MA and intellect were in fact, not related, and it could be an issue for anyone, even those that seemed "proficient" in mathematics. It highlighted the damaging negative attitudes students had about mathematics since many students believed smart people would not struggle with mathematics at any stage and mentioned this as the key thing they had learnt from the intervention (as shown in Section 6.3.3), again supporting the need for increasing students' MR. These damaging attitudes appear to inhibit engagement with MSS since students shared their surprise at learning that staff at **sigma** had also struggled with mathematics and statistics. Many followed this declaration by sharing that there was a fear and concern around their questions about mathematics being easy, which may be why students do not seek support until their mathematics worries get sufficiently "difficult" (such as in the prior example of nursing students not often seeking support on understanding percentages, which they may perceive as a topic they should already know, but attending when they need help for drug calculations). This is further supported by statements made by students in the engagement questionnaire and interviews. These statements are reported in Chapters 7 and 8. They also appeared to see the staff at **sigma** as people that were unable to make mistakes and those that would not understand their struggles with mathematics. In fact, one piece of feedback received from a student was, "*I now know that the tutors were in the same position like me once where they needed help and support and they won't think my questions are stupid*".

These are all traditional beliefs that reinforce low MR and are actually also a statement on the MR questionnaire (Kooken et al., 2013) as "*only smart people can do maths*" and "*people who work in Maths-related fields sometimes find Maths challenging*". However, in the post-intervention questionnaire, for the former statement, all students responded they either completely disagreed or disagreed with this statement (aside from one "neutral" response), and all but three (who responded neutral) agreed or completely agreed with the second statement. It is interesting that some students may have responded in the pre-intervention questionnaire and disagreed with such statements, but verbally, or at least mentally, agreed since during the intervention sessions, it was repeated often that it was a surprise that MSS staff and lecturers could struggle with mathematics, and it was, as mentioned above, noted in the feedback form, too. Perhaps there is a difference to be found here in the responses students may give to a questionnaire when asked about their feelings towards mathematics, wherein there is a disconnect between what they know (all people can struggle with mathematics) and what they perceive or believe (they are alone in their struggle). Thus, the intervention may be useful in challenging these negative beliefs that may have not been translated across to their overall MR score, and as such, a student with a high MR score should not be excluded from such interventions.

6.5 Summary

The results from this chapter are indicative of the value of personalised interventions in changing perceptions of MSS and increasing engagement. In particular, the case of Participant 4 highlights the impact of the intervention on an individual student. 86% of students state they are more likely to use **sigma** due to the intervention. One of the students who responded that they were not more likely to engage stated that they were already aware of the support and had sought it out prior to the intervention. 54.5% of students engaged with MSS after the intervention. Whilst quantitative results show no significant difference in the MA and MR of students prior to and following the intervention, it is important to recall the sample size as well as the timing of responses for some of the post-intervention questionnaires.

However, when students were split according to the form of intervention delivery, though again there was no significant difference in the pre and post-MA and MR scores of participants, it appears that online delivery may be of more benefit particularly to mathematically anxious students. It may be that since almost half of the face-to-face students completed the questionnaire around their exam period and most answered the pre-MAMR questionnaire at the start of their academic year, this may have affected their reported MA.

Key findings from this chapter are reported below:

- For students that are aware of the availability of MSS, an increase in their MA over the academic year indicates that such a student is likely to have an increased number of visits to the drop-in centre if the academic year being considered is the year students from that course usually visit in. This may be explained by students seeking support when they are in the "anxiety" zone of the growth zone model. An increase in MA may be because they are uncomfortable with the mathematical content they are faced with and because of their upcoming exams. Therefore, they move from the growth zone to the anxiety zone, but because the students have an understanding of how to learn effectively and where to seek support due to the intervention, they engage with structures such as MSS, to therefore expand their growth zone.
- Conversely, if the academic year being considered is *not* the year students from that course usually engage in, student visits decrease in that year if their MA increases. This may be due to their increase in MA not being related to mathematical content (since for most students, the year they typically engage in is the predominant year in which they have mathematics-related assessments).
- Online interventions for reducing MA may be more beneficial to anxious students, and this may extend to online support, too.
- The change in MA and MR for students from before the intervention was not significant.
- 86% of students said they were more likely to use MSS due to the intervention.
- Around 55% of participants engaged with the centre after the intervention.
- MR score does not significantly predict engagement, nor does a student's change in MR score.
- The intervention may be beneficial as an advertising tool for **sigma**, particularly for anxious students to ensure they know support is available should they need it and that the staff are not judgemental. Barriers such as not knowing how to access the support should be minimised.

- Qualitative feedback for the intervention was broadly positive, with many responses highlighting its benefits.
- Due to the small sample size, these are exploratory findings, and as such, these results indicate trends in engagement. Further investigation is necessary to support these findings.

7 Why do students engage with MSS?

7.1 Introduction

In the previous chapters, it was found that a plethora of characteristics affected the engagement of students. An engagement questionnaire was delivered to students to understand better how students viewed both MSS and engagement with MSS. Users and non-users of MSS of different demographic backgrounds were targeted to ensure a varied sample of students.

The findings of this analysis will answer, in part, RQ4, which is:

RQ4) How do students explain their level of engagement with MSS?

The specific RQs this chapter aimed to address are as follows:

SRQ1) What are student perceptions of sigma?

SRQ2) How does MSS rank in options of support available to students?

SRQ3) To what extent do students attribute affective reasons for their own and other students' engagement and non-engagement?

SRQ4) How can students be encouraged to use MSS?

The chapter will begin by briefly discussing the methodology used and providing an overview of the sample of students that answered the questionnaire, including whether they were users or non-users of the support. It will also report on students' understanding of what MSS is and who it is for, along with their reasons for either engaging or not engaging, what would encourage engagement, how affective reasons impact their engagement, and finally, how MSS ranks in options of support.

7.2 Methodology

7.2.1 Questionnaire design

As detailed in the methodology chapter, open and close-ended questions were used to gauge which factors affected student engagement. For the question on student competency in mathematics and the question on how emotional reasons affect student engagement with MSS, a five-point Likert scale was used so that students would have a "neutral" option. However, when asking students about the level of mathematics in their course, a four-point Likert scale was used, with the neutral option as the level of mathematics in their course staying the same.

When students were asked about engagement with MSS, it was decided that a list of options would be presented to students so that it was clear that not only drop-in engagement was considered overall. The same was done for the question on what other forms of support students may use, with students asked to rank each option according to the likelihood of them using that form of support. One response category allowed students to mention other options for support. This was to determine how and whether **sigma** was considered an avenue of support when students faced a mathematical/statistical problem.

Students that had yet to engage were asked what would encourage them to use the support. The question was worded like this, rather than directly asking them why they had not engaged, so that students would not immediately feel as though they were being attacked for their non-engagement; if they felt like this, it may have led to them providing shallow reasons for their non-engagement, rather than their actual reasons.

Responses to open-ended questions could occasionally be categorised as being in more than one response group. For example, "*I had a math exam approaching, and the pass mark was 100% on nursing calculation*" is categorised in the group "exam", whilst "*if my teacher has taught something and I don't understand, I go to* ***sigma*** *so that I can get it explained by someone else in a different way and maybe that will help me understand better*" is placed in "different teaching methods". However, "*been a while since I have done maths, so I feel very anxious and need extra help with math. Other modules I'm fine with, but I feel like maths is taking up about 90% of my time*" is in the group of "course help", "anxiety", and "age".

7.2.2 Recruiting participants

The questionnaire was open from September 2020-July 2022. This (long) time period spanned the pandemic (when support was online only) and after the pandemic (when both in-person and online support was available). The questionnaire was left open for this length of time to ensure a large and representative enough sample size. The first response came on 10th February 2021 because of issues with collecting data due to the pandemic, with most responses received from September 2021 to February 2022. An opportunistic sampling technique was used since emailing students or contacting them through Teams resulted in a near non-existent response rate. Therefore, lecturers were invited to ask students to participate, research centres were also contacted, and the questionnaire was advertised online and in the physical MSS centre in the library. Some students filled in the questionnaire multiple times; in this case, only their first response was considered. The questions used can be found in Appendix 2.

7.2.3 Sample

One hundred and nine responses were given to the engagement questionnaire. However, four responses were removed as duplicates, with another removed due to missing data. Only eight students completed the questionnaire in 2020/2021, which is partially explained by the fact that, at this point, students were primarily studying online. In-person MSS provision was limited to six pre-booked desks at a time until December 2020, when government guidelines halted face-to-face support again until May 2021. From September 2021, students moved from mostly online learning to being on campus, and the MSS provision changed to accommodate this. During 2021/22, mostly face-to-face support was offered, with some online hours available. Although MSS provision was different over the two academic years, the analysis was done on the whole dataset due to the small sample size for the first year if the analysis had been performed separately. The findings will be more applicable than those found during the pandemic since the current provision more closely mirrors that found in 2021/22. Thematic analysis was used to analyse the responses.

The demographic characteristics of student respondents and whether they engaged with MSS services can be seen in Table 7.1. Since some student data was missing, the table totals may not always amount to the total number of students. In some cases, students did not provide correct ID numbers, so it was not possible to obtain their information from the University system.

Table 7.1

Student characteristics and engagement with MSS status of respondents

Student characteristics	Users	Non-users	Total
Female	17	35	52
Male	13	34	47
Mature	19	30	49
Non-mature	11	40	51
Disability	4	6	10
No disability	26	64	90
Mathematics A Level Required	8	2	10
Mathematics A Level Recommended	5	9	14
No mathematics A Level Requirement	17	48	65
PhD	1	9	10
White	17	28	45
Asian	6	18	24
Black	1	8	9
Mixed	3	2	5
Other ethnicity	1	2	3
Unknown ethnicity	2	12	14
UK	21	43	64
International	9	27	36
Year 1	12	36	48
Year 2	7	20	27
Year 3	9	12	21
Year 4	2	0	2
Year 5	0	1	1

7.3 Questions

7.3.1 Student perception of MSS

Chapter 4 shows that, before the pandemic, students on highly mathematical courses availed of **sigma**'s services the most. This may be because the service is advertised more heavily to students on these courses, because students recognise peers in proctoring roles, which encourages their attendance, or because their course has more mathematical content, so there is more scope for needing "course help". However, it may also be due to the false perception that MSS is solely for students on mathematics-heavy courses. However, during the pandemic, it was, in fact, students from health-related (i.e., mathematics-light) courses that engaged most. To therefore gauge students' understanding of the role of MSS, students were asked:

> *"What do you think MSS is?"*

And,

> *"Who do you think MSS is for?"*

An overwhelming number of responses mentioned poor mathematical ability/skills/ achievement, suggesting that students believed MSS is "remedial" support rather than support for all students and staff, regardless of mathematical competency. It is unclear what directs students into thinking it is remedial since O'Sullivan et al. (2014) reported that students in Irish institutions did not see their centres in this way. Comments from students included:

"A platform for students with low maths skills to get up to the [sic] *par with their course requirement."*

"[for] *people that find maths easy that can teach this to those more uncomfortable with maths."*

Some responses indicated that students believed MSS was for students who did not enjoy mathematics. This perhaps highlights that students believe struggle is not common for "smart" students and that only those struggling students who dislike mathematics must use the support available. Such beliefs are an indicator of low levels of MR. This belief is highlighted in the following quote:

"[MSS is] *support for students who don't enjoy doing maths and therefore struggle with it."*

Interestingly, students also mentioned that MSS was particularly for anxious students. Indeed, it was suggested that MSS is for:

"People with worries or anxiety about maths."

"Helping students with getting over their anxiety of doing maths and giving them help in the areas they struggle with."

Since one of the aims of this research is to understand firstly whether anxious students are availing of the support and secondly how to encourage anxious students to use the support, this provides some evidence that some students (not necessarily students that are MA) see the centre as a place where mathematically-anxious students can seek help.

7.3.2 Student perception of competency in mathematics

Students were also asked to rate their competency in mathematics to determine whether a relationship existed with how they viewed their ability and their engagement with MSS. The responses can be seen in Table 7.2.

Table 7.2

Students' self-reported competency in mathematics

Option	Count
1 - Excellent	4
2 – Good	29
3 – Average	52
4 – Unsatisfactory	12
5 – Poor	6

A Spearman's rank correlation test was conducted to determine the relationship between the perceived competence of students and their number of visits to MSS since both were ordinal variables. This returned ρ (35) =0.28, p=.871, showing no statistically significant relationship existed.

The relationship between the variables is further highlighted in Table 7.3.

Table 7.3

Cross-tabulation of self-reported mathematics competency and engagement of students

Competency	Total visitors	0 visits	1	2	3	4	>5	Total visits	Average number of visits per visitor	% who visited
Excellent	1	3					1	62	62	25
Good	7	22	1	3		1	2	64	9.1	24
Average	12	40	4	1	3		4	60	5	23
Unsatisfactory	8	4	3			2	3	45	5.6	67
Poor	1	5	1					1	1	17

When looking at total visits, including any outlier values, it can be seen that, broadly speaking, there is a relationship such that the better students believe their mathematical competency to be, the more frequently they visit the centre. This table shows that weaker students were somewhat less likely to engage with the centre, though interestingly, one student who ranked themselves as excellent in mathematics visited the centre 62 times. This indicates that the students who rate themselves as having a high competency in mathematics use the centre socially to work since some visits are quite high (such as one student in the good category who visited 48 times).

There is very little difference between excellent, good and average students in terms of the percentage who engage. Still, the frequency of their engagement decreases alongside their assessment of their competence. Those who believe themselves to be unsatisfactory engage at the highest rate by some distance (67%), but those who do visit do not come as often as students in the good and excellent groups. Those who believe they are poor at mathematics have the lowest engagement rate at just 17% (i.e., one student), and the average number of visits per visitor is 1. It might be inferred from this that “poor” students tend to regard themselves as "lost causes", so there is no point in them engaging with MSS because they cannot improve, indicating a fixed mindset (Dweck, 2000).

Spearman’s rank correlation was again computed to investigate the nature of the relationship between students’ MA scores and perceived self-competence and MR scores and perceived self-competence. There was a significant weak-to-moderate negative correlation between MR score and perceived self-competence (with 1 representing excellent competency), $\rho(75)=-.315$, $p=.006$, which meant the more someone perceived themselves as competent in mathematics, the higher their MR score was. The MA score showed the opposite trend: there was a strong significant correlation between MA and perceived self-competence, with ρ (76) =.704, $p<.001$, which meant the more someone perceived themselves as competent in mathematics, the lower their MA score was.

Therefore, perhaps as expected, the higher students rate their mathematical competence, the lower their MA score and the higher their MR level. This may be related to gender and perception of mathematical ability; despite no difference in mathematics achievement, male students have higher self-perceived mathematics competence than female students and typically have lower MA scores (Skaalvik & Rankin, 1994).

When students were asked further if they had considered dropping out of university because of difficulties with the mathematical or statistical elements of their course, 24 students answered that they had. These students were then asked if the availability of MSS had encouraged them to remain at the university. Of these 24 students, 15 responded that MSS had had a positive impact, meaning approximately 63% of these students felt that the availability of MSS supported them in staying on course, similar to the 62.7% who responded the same in O’Sullivan et al.’s (2014) survey.

7.3.3 Course

Students also spoke about the level of mathematics/statistics they wanted on their course.

Table 7.4

Student opinion on the level of mathematics in their course

Opinion on mathematics in course	Frequency
1 - I wish there was more maths/stats in my course	13
2 - The amount of maths/stats in my course is about right	55
3 - I wish there was less maths/stats in my course	24
4 - I wish there was no maths/stats in my course	11

A Spearman's rank correlation test was run to determine the relationship between student opinion on the amount of mathematics in their course and their perception of their mathematical ability. This returned a significant weak-to-moderate positive correlation, with ρ (102) =.381, p<.001. Akin and Kurbanoglu (2011) found that MA was negatively correlated with mathematics attitudes and self-efficacy, with one question on the attitudes scale being*, "I would not enjoy working with mathematics"*. Understandably, the lower a person ranked their mathematical ability, the less mathematics they wanted in their course.

The relationship between opinion on the amount of mathematics and student engagement with MSS can be seen below.

Table 7.5

A chi-squared table on actual and expected engagement with ***sigma*** *split by students of differing opinions on the amount of mathematics on their course*

Level of mathematics		Engagement		
		Not visited	**Visited**	**% visited**
More maths	**Count**	11	2	15%
	Expected count	9.2	3.8	
Same	**Count**	38	17	31%
	Expected count	39.0	16.0	
Less	**Count**	15	9	38%
	Expected count	17.0	7.0	
No maths	**Count**	9	2	18%
	Expected count	7.8	3.2	

A chi-squared test was used to investigate this since both variables were categorical. This returned χ2 (3, N = 103) = 2.727, p = .436, meaning there was no significant relationship between the two variables. However, when considering the percentage in each group that engaged, this forms an inverted-U shape, similar to that of the Yerkes-Dodson curve (Nickerson, 2023). It may be surmised that those who want more mathematics feel very comfortable with the level of mathematics on their course (and may have lower levels of MA), which is why they would want more mathematics, and so are primarily in the group of students who feel that they do not need help. However, those who want no mathematics may be students that wish to avoid mathematics (potentially due to high MA) and are unlikely to use the support. The group who want less mathematics in their course may understand that it is necessary (which is part of the value scale of MR) and visit in the highest proportion. They may also be more MA.

7.3.4 Engagement with MSS

One of the first questions asked students whether they had engaged with the support and, if so, with which services. **sigma** keeps records of students who use either the drop-in service, appointment service or workshops, although there is no record of those who use the online resources.

Table 7.6

*Count of student engagement with varying **sigma** supports*

Options	Count
Drop-in centre at the library	19
Online drop-in centre	16
Resources from the **sigma** website	16
Workshop	11
Email support	8
Pre-booked appointment (online)	3
Pre-booked appointment (face-to-face)	2
I have not used any of **sigma**'s services.	69

Forty students said they had used some form of the support available; when this was cross-checked against **sigma** drop-in attendance records, only 31 of these students appeared in the **sigma** records. However, this may also be because 16 students said they had used web resources, which are not currently monitored. It may also be because there had been a recording error or the student forgot to sign in when using the support; students are asked to scan their cards upon entering the physical centre. The drop-in service is only one of the services offered, and more should be done to monitor website usage in more depth to understand its level of success, too.

7.3.5 Why students engage

The question posed to students that had used the service was:

> *"What was your main reason for engaging with **sigma**?"*

A summary of the reasons given can be found in Table 7.7. Since it is evident that the key theme for this response is "course help", all reasons were mentioned in the following table.

When this is also the case for the other questions, all reasons are again mentioned in the tables rather than just the themed answers.

Table 7.7

Summary of reasons for engaging with MSS

Response theme	Number of responses
Course help	26
Research methodologies	2
Age	2
Study space	2
Exams	2
Affective reasons	2
“real-time” support	1
Intrinsic motivation	1
How **sigma** works practically	1
Advised to	1

It is clear to see that the principal reason for students seeking support was for course help. This ranged from students specifying topics they needed support with, to describing gaps in their knowledge that had occurred, for one student, due to lockdown, and for two students, the time they had been out of education. These are highlighted in the following quotes:

“After listening to several maths lectures in my maths module, it was quickly apparent to me that I was out of my depth. I left college in 2003 and have pretty much forgotten any maths I learned.”

“Not understanding a maths topic as for lockdown was not taught to me during A level.”

Two students also highlighted the centre as not just a space to get course help but also as a study space:

“Either just go there to work individually or needed help on tutorial questions.”

Fear of failure also played into one student’s reason to seek support:

“I was scared to fail my module.”

This was classed as an affective reason. From two other responses, it was again clear that many students did not perhaps have a concrete understanding of **sigma**, as highlighted in questions 1 and 2. Students mentioned using the centre to discuss research methodology. It may be that the student was talking about research methodologies in the context of statistics, but this was not made clear by their answer:

"To refresh my knowledge of the basics of research methodologies."

Another student specified they had visited the centre solely to see how it operated, highlighting that advertising of the services is not as straightforward as it ought to be.

Although students seeking support through MSS for course help is the main reason for their engagement, it is clear from the above that the motivations behind why they seek course help may differ. From needing course help because of time away from education to needing course help because of fear of failure, deeper investigation through interviews may be more fruitful.

7.3.6 What would encourage non-users to engage

A table of all categorised responses to what would encourage non-users to engage can be found in Table 7.8.

Table 7.8

Summary of what would encourage students to engage

Response theme	Number of responses
If course help was needed	15
Affective reasons	10
Better understanding of **sigma** services	9
More information	6
Relevance/use in future	6
Advertising	4
Not needed	1

Again, as found in previous research (O'Sullivan et a., 2014; Symonds et al., 2008), the primary answer students gave, even when the question was worded differently, was that if support were needed, they would use MSS, with the inference that they had not yet needed the service. As found in O'Sullivan et al.'s (2014) research, students that answered they would engage if course help was needed typically rated themselves as competent in mathematics, with six students rating themselves as average, nine rating themselves as good, and only one rating themselves as unsatisfactory. The response this student gave was more specific than other answers:

"My low performance in understanding the coursework and difficulty in understanding the course."

Other responses for this category (from those that had rated their mathematics competency as average or good) were more general:

*"I intend to use **sigma** in the future."*

"If I don't understand a topic, I would seek help from ***sigma****."*

There was also again a clear indication that students did not fully understand what **sigma** was; however, this time, some of the students themselves spoke of it:

"I need more information [than] that, do I need to book to arrive [use] *the centre."*

"That I need extra information on the ***sigma*** *support."*

Others did not know they had misconceptions or a lack of knowledge on **sigma**. For example, **sigma** offers both online and face-to-face drop-in support, yet students mentioned that if this was available, it would encourage them to avail of the service. These responses are all grouped in the "better understanding of **sigma** services" category:

"If there was a drop in type session."

"Maybe if there is a way to get help online and not face-to-face?"

In this category, two students mentioned not being aware of **sigma** and the services offered:

"I was not aware of ***sigma*** *or what it offers."*

Some students made suggestions about what could be put in place for students, mentioning the need for tailored advertising:

"More advertisation [sic] *about it, learning about how it can help me."*

Another also gave a thoughtful response about how this increase in successful advertising could be achieved:

"Include a ***sigma*** *session in a lecture of* [or] *workshop to see a face/s behind the this* [sic] *service."*

This mirrored some other responses given:

"If I had already met the people that work there."

"It seems intimidating, so less formality."

More familiarity with both the service and the staff seems key. It appears that some students may see the centre as intimidating so clear structure and understanding of the service may benefit these students in particular:

"I don't know how to access it, and as someone with anxiety I want to know exactly what I'm doing before starting."

This anxious student did manage to engage with the centre at a later date. However, the above quote further highlights how more effective advertising, particularly around procedures of how to seek support, is of paramount importance. It also shows how some students have given affective reasons for their non-engagement, such as their anxiety being the factor that hinders their engagement.

In fact, it has been suggested by Symonds (2009) that students may provide structural reasons for their non-engagement, e.g., times did not suit, did not know where the centre was, as a cover for their actual affective (emotional) reasons for not engaging, such as being embarrassed. This was supported by Grehan et al. (2011) with a small sample size consisting of students that had failed a first year mathematics module. Aside from two students not knowing about the existence of the service, structural reasons were not cited as a reason for student non-engagement at all in this questionnaire, providing some evidence to support the statement made in Symonds (2009). Asking open-ended questions about student non-engagement rather than giving students a predetermined list of answers they can select from, as was used in O'Sullivan et al. (2014), may also have aided this.

7.3.7 Do students have affective reasons for their non-engagement?

To investigate this hypothesis around affective reasons for non-engagement, one of the questions further asked to all students was:

"Some people have indicated that they are reluctant to engage with maths and stats support because of emotional reasons such as being afraid that others will look down on them for seeking help; feeling uncomfortable asking for help; thinking their questions are so basic it will be embarrassing, etc. On a scale of 1-5 where 1 is not at all and 5 is very much, how much do these kinds of reasons apply to you?"

The responses can be found in the following table.

Table 7.9

Student answers to whether their engagement with MSS is affected by emotional reasons, split into whether students have engaged

Score	Engaged	Not engaged	Total
1 – not at all	13	18	31
2	4	16	20
3	6	12	18
4	4	20	24
5 – very much	3	7	10

The totals in this table do not add up to the correct total since 1 student did not answer the question.

Thirty-four students answered 4 or 5 to this question, meaning affective reasons were a substantial reason why they did not want to engage (although seven of these students had engaged). 51 responded with either 1 or 2, whilst 18 answered 3. Those that responded with 1 or 2 and did not engage may be those that are mathematically capable and do not feel they would benefit from the support. 33% of these students are deterred from seeking support not necessarily just because of a lack of advertising or even because of a lack of support but because they potentially do not feel comfortable seeking help. It may be that if clearer information about how **sigma** operates was more readily available, students may feel more comfortable with attending, especially since many students have mentioned feeling intimidated or wanting more information before taking the step to engage. Furthermore, of these 34 students, 27 had not sought support. Of those who did not engage, 37% of students answered 4 or 5, whilst, for those that had engaged, it was 23%, so affective reasons hindered more students than they had encouraged.

What was also interesting was that the students who answered 4 or 5 to this question tended to be female (22 students, 65%), mature (17 students, 50%), home (25 students, 74%), and white (16 students, 47%). Six of these students were disabled (18%). These students also mainly appeared to be studying courses that have either no mathematics A level requirement (19 students, 56%) or a recommendation (8 students, 24%). Excluding white and non-disabled students, these students were those found to be more MA in Chapter 5.

A follow-up question asked them: "*Please indicate which reasons affect you most*". These reasons refer to the potential responses given in the first part of the question. The reasons given by students have been grouped together in Table 7.10.

Table 7.10

Responses to what affective reasons students attribute to their non-engagement

Reasons	Number of responses
Looking stupid	8
Basic questions	8
Embarrassed	8
Concern around lack of knowledge	7
Uncomfortable asking for help	4
Imposter syndrome	3
Everything	3
Difficulty wording questions	2
Critical teachers	1

Most responses were related to embarrassment such as the worry of asking "basic questions", though, for the sake of clarity, these responses have not been grouped together in Table 7.10; themed answers are in Table 7.11. Most concerns appear to be around either being perceived as stupid or seeing themselves as stupid, which would result in embarrassment. The concern around lack of knowledge is also related to this.

Table 7.11

Grouped responses to what affective reasons students attribute to their non-engagement

Reasons	Number of responses
Looking stupid/embarrassed	16
Basic questions (*may tie in with embarrassment)*	8
Concern around lack of knowledge	7
Uncomfortable about asking for help	4

Despite **sigma** being a space for questions to be asked and to improve knowledge, it was interesting and somewhat disheartening to see how many students were deterred from asking for help because of this concern around asking "basic" questions or being concerned about their lack of knowledge:

"Struggling with basic issues and getting worked up/ upset is embarrassing."

"Asking questions which might be too basic for other students. I am good at understanding things, but for maths, I have always been far slower. This makes me feel embarrassed, I have completed me [sic] *bachelor's having only trouble in maths, not in any other things."*

One student specified that it was amongst their fellow students that they did not want to appear stupid:

"Fear of looking dumb among my peers."

Some students also seemed to just have a general concern about asking for help. Whether this ties in again to anxiety around being seen as stupid is unclear:

"Feeling uncomfortable asking for help."

In some responses, it seemed students struggled with imposter syndrome (Bhosale, 2022). Not being good enough to be on their course was one such reason, and in another, a PhD student expressly mentioned that they had imposter syndrome:

"Feeling stupid and not good enough, feelings of struggling."

"Imposter syndrome. I feel as a PhD student I should know it all, so there is a fear of being judged. I also worry my questions are embarrassingly basic."

"Fear of people thinking I'm not smart enough to do my degree."

Overall, how students are perceived by others for seeking help and how they perceive themselves seem to be the key reason why they are not seeking support. Some students have even mentioned the visceral reactions they have when they are struggling with their work. Whilst a few students have directly identified anxiety as their key affective reason for not engaging, there is not much distinction between general anxiety and what may be specifically MA, though, in Chapter 8, students do specify that their anxiety was about mathematics. In some cases, it appears that it may be MA students are struggling with, such as:

"Although I find maths very interesting I had a teacher that has been continuously discouraging and critical of my inability to understand maths naturally, without thorough explanations."

However, it bears noting that interventions aimed at increasing MR and decreasing MA may also have the additional effect of helping students overcome any general anxiety they have around seeking support.

7.3.8 How would users of MSS encourage others to engage

All students were asked what would encourage others to seek support. The suggestions given can be found in Table 7.12.

Table 7.12

Responses to how all students can be encouraged to seek support

Response theme	Number of responses
Advertising (excluding sub-categories)	17 (non-threatening – 5, more information, 15)
Student testimonials	9
Affective reasons	3
Showing effectiveness	2
More varied staff	1
Time	1

Somewhat surprisingly, few students mentioned emotional reasons when asked about encouraging the engagement of their peers, in comparison to when students were asking how they would themselves be encouraged. This perhaps highlights that for the previous question where non-engaged students were asked what would have encouraged them to engage, they were very aware of the affective hindrances to their engagement as they had not yet managed to overcome them. However, in this question, which was open to all students, some students had engaged and had potentially already overcome emotional hindrances. They perhaps did not realise that other students may also have felt as they did about mathematics/statistics and engaging with the centre, which appears to be a theme where students feel as though they are alone with their mathematical struggles. Another student's response showed how mathematics is perceived.

"Tell them it isn't a sin to be bad at maths, maths is a skill which needs to be trained. That's how you get better. Don't be afraid."

This comment highlighted how other students potentially see mathematics as either something they are good at or not. Mentioning that it is not a sin seemed particularly evocative and put previous comments by students about their dread of asking basic questions or embarrassing themselves in a new light. It was also a very supportive comment, and it can help to understand why student testimonials were seen to be particularly effective. Students may perhaps believe their peers can understand their predicaments better than staff can. The response also seems to be saying that affective reasons need to be addressed since non-engagers fear being judged and also that they are afraid of engaging:

"Discussing how helpful it's been. I accessed **sigma** *after another student told me how useful it can be for stats support."*

"Consistent awareness raising is important."

"Remind them of its existence."

In advertising, five students mentioned that knowledge that the space is non-threatening could encourage student engagement, again showing the importance of **sigma** being a safe space where students do not feel judged for asking for help:

"Making it known that students won't be judged at all for being bad at maths and that what help they need can be worked on together, as sometimes the student may not know what they don't know or what to do, and may worry about feeling stupid."

"Make it a safe space, maybe implement some fun activities to make it less of a study centre ONLY but also a relaxed zone."

Fifteen of these responses were about needing more information on **sigma** for students to feel comfortable with using the support, with some students again suggesting ways in which the service could be advertised more effectively:

"Give more information on how to access the services more actively."

"By witnessing how a drop-in session progresses even for those that have very limited understanding in maths."

"To have a tour around the facility would ease the students that really want to get help."

Students perhaps may feel anxious about using the support because they are unfamiliar with the staff, and this might feed into their ideas that they will be judged for not knowing enough mathematics:

*"Include a **sigma** session in a lecture of* [or] *workshop to see a face/s behind the/this service."*

"By letting them know on [sic] how friendly the team is if they want to visit them."

One student even mentioned that student anonymity may be something that encourages students to visit, again reinforcing the suggestion that students do not want to be recognised or perceived as "struggling" or needing help:

"Maybe adding an anonymous live chat option might be beneficial for some people if they don't want to speak to anyone or for anyone to know who they are."

It may be that if students only see the word **sigma**, and it is not followed by maths and stats support, they are unfamiliar and uncomfortable with the **sigma** and see it as a place to avoid. Anecdotally, a student mentioned to the researcher that the name **sigma** was intimidating to them. This was also mentioned by another student as a response to this question.

*"**sigma** is a scary name - maybe change it? An open-door policy? I think I have seen **sigma** in the library, but it looks like a closed-off space? I am an online student, so physical access to **sigma** is not possible on a day-to-day basis. This is true for me even though I live in *. It is probably more of an issue for other people on my course who live overseas."*

This highlights that there is potentially a difference between how **sigma** is viewed from an online student perspective as opposed to a "traditional" student perspective, which may have been heightened due to the changes to teaching since the pandemic. This student also appears to be unaware of the online support that is offered, so engagement does not have to be in-person as this student believes it to be.

7.3.9 What other avenues of support would students seek?

Finally, all students were asked:

"If you were struggling with the maths/stats in your course, please rank the following in the order of what you might do about it (with 1 being the option you would choose first)?"

The ranking given for each action can be seen in Table 7.13 below.

Table 7.13

Frequency of responses to what avenues of support students would seek if struggling with the mathematics/statistics content in their courses

Action	Ranking				
	1	**2**	**3**	**4**	**5**
Do nothing, just try to get by as best I can	13	11	14	12	48
Talk to other students	19	33	25	16	5
Ask one of my lecturers/tutors for extra help	19	18	30	25	7
Look on the internet or in books	55	13	11	13	8
Visit the University's MSS service	13	21	20	26	19

The action taken first by most students would be to look on the internet or in books. This is a commendable reaction and one that may speak of students developing as independent learners. Alternatively, it might be related to topics discussed earlier about students not wanting it to appear as though they are not coping with their studies in front of peers or staff. Seeking help from other students or lecturers is a long way behind as the joint next most common first course of action. Somewhat worryingly for MSS providers, as many students would do nothing as a first course of action (13 students) as would come to MSS.

The action which most students would be least likely to take was to do nothing, and this was a long way ahead of visiting MSS as the second least likely action to be taken.

As a follow-up question, students were asked,

"Are there any other things you might do?"

The (ungrouped) responses can be found in Table 7.14.

Table 7.14

Alternative forms of support sought out by students

Response	Number of responses
External support	10
Time	3
Videos – how to and tutorials	1
Take a course	1
Would only use **sigma**	1
Online platforms	1
Books	1
Give up	1
Lack of understanding on **sigma** services	1

Most responses repeated options that had already been offered (at least in part) in the first part of the question, such as books, online platforms or videos. The one answer that occurred most was that they would seek external support, such as asking friends or family for help, despite this being an option in the first part of the question:

"Ask to do group work with my friends and guide each other."

"Ask my dad, or peers."

One student even said they would give up:

*"Honestly I would give up before it got to asking others/friends/tutors/**sigma** for help. For fear of them judging me, or explaining it and me not understanding and feeling stupid."*

Again, not wanting to ask for help was for fear of looking stupid around those that may judge them.

A few different responses were categorised under time, which can be seen below. One student simply wished they had more time, whilst others speak about the importance of using their time wisely:

"Find more time."

"Review notes taken from lectures in my own time at my own pace."

"I do not have a personalised tutor or have a clue who they are. If there was no support, I would have left stuff and played video games give me a mental health break and comeback to rethink about the question."

7.4 Discussion

This chapter shared the results of an engagement questionnaire that sought to understand the reasons behind student engagement and non-engagement with MSS. A series of questions covered topics such as student perception of MSS, student reasons for engagement and non-engagement, students' perception of their ability in mathematics, how much affective reasons hindered engagement, and what avenues of support students would seek should they need help with mathematics.

Analysis of the engagement questionnaire shows that just as engagement itself is a multifaceted construct, reasons for student engagement, or lack thereof, are also multifaceted. There are many factors that must be considered when attempting to identify how engagement with MSS can be increased successfully. When students do not seek support through MSS, their primary source of support are firstly impersonal learning resources (such as the internet of books) followed by their peers. This suggests that students feel most comfortable seeking help without exposing themselves to others and when this becomes necessary, seeking help from those who they feel are less likely to judge them for needing assistance. One concerning finding is that as many students would prefer not to act when struggling with mathematics as a first option than use MSS.

Student responses to what they believe MSS is and who it is for suggest a flawed and potentially damaging perception of MSS. Mention is made of weak students especially, indicating that there is perhaps a misconception that **sigma** is only remedial support. Conversely, O'Sullivan et al. (2014) found that, in a survey of nine different institutions around Ireland, their MLS was viewed as being for all students, regardless of ability.

What is especially concerning is how students also responded to the question about how affective reasons hinder their engagement. This appeared to be quite closely connected to their perception of their own mathematical competency and their understanding of **sigma**'s services. The main affective reason suggested was fear of embarrassment, or closely tied to embarrassment, such as being afraid to ask basic questions or being afraid to be seen as stupid. This is supported by work previously carried out by Grehan et al. (2011) who found fear was one explanation given that inhibited engagement with MSS: this could be fear of failure or fear of showing a lack of ability, which is similar to the findings reported in this chapter. In O'Sullivan et al.'s (2014) research, fixed responses were used to determine student reasons for non-engagement, including structural reasons such as not knowing where the centre was or timings not suiting. When designing the engagement questionnaire, this was taken into account, and so open-ended questions around engagement were asked instead, as well as specific, probing questions around whether affective reasons influenced engagement, particularly since Grehan et al. (2011) used open-ended interviews when finding fear was a factor. In total, 33% of students responded that affective reasons did hinder their engagement when fixed responses were not used, whilst no student gave structural reasons for their non-engagement. However, several students gave responses around either not understanding how **sigma** worked directly or their answer indicated they did not know how it worked. This has previously been unexplored as a factor in why students do not engage. This finding suggests an answer to the question raised by Symonds et al. (2008) on whether students gave structural reasons for their non-engagement as a mask to affective reasons. It was suggested that where students may not want to admit they do not know how MSS works, they select the fixed response categories of "I do not know where MSS is", or "the times did not suit".

As aforementioned, student perception of self and how they are perceived by others affects engagement considerably. This fear around being perceived by others as lesser or stupid seems predominant as it appeared in more answers (e.g., *fear of looking dumb among my peers*), though this by no means should be interpreted as though their perception of themselves (*feeling stupid and not good enough, feelings of struggling*) does not also influence their engagement. The importance students place on how they are perceived may also have some bearing on the level of MA they have. Some responses did point to the respondent having some level of MA, such as: "*Although I find maths very interesting I had a teacher that has been continuously discouraging and critical of my inability to understand maths naturally, without thorough explanations*".

This illustrates the paramount importance of shifting student attitudes away from **sigma** being only for students who may have some difficulty with mathematics in order to increase the engagement of *all* students.

Currently, **sigma** is advertised to students at the start of their academic year and is usually also advertised on Aula, too. Since the beginning of the first year is a time of receiving a large volume of information in a short amount of time, it may be that **sigma**'s availability is washed away by what students deem to be more important (especially since mathematics support may not be so necessary right at the start of the course). Reminding students again of the service once they have begun the mathematics content of their course, particularly for those with only a small mathematical component to their course, may be of use as this idea is mentioned several times by students. More effective advertising and communication is also discussed, such as detailing how support can be accessed and how it works, that the ethos of the centre is to be welcoming and non-judgemental, and that the staff do not regard any questions as being too basic. It is clear to see that the advertising needs to address some of the affective reasons for non-engagement. Using student testimonials is one method that is endorsed by students. This builds upon previous literature (O'Sullivan et al., 2014; Symonds, 2009) that discusses advertising as being mentioned by students. O'Sullivan et al. (2021) explained how support systems should be straightforward to navigate, signpost students quickly and clearly, and create tailor-made resources to encourage engagement. Symonds (2009, p.140) stated, *"This poses the question: would simply implementing the above suggestions [advertising strategies] be enough to improve the uptake of support amongst failing students?"* The findings herein about advertising needing to address the affective reasons for engagement are new and provide key context to previous statements made by students; thus, it is hoped that tailoring advertising strategies will make some progress towards engaging students that currently do not use support but would benefit from doing so.

7.5 Summary

The engagement questionnaire provided novel insight into why students choose to engage (or not) and how non-engagement may be remedied. Student testimonials are believed to be an effective method of advertising support as it seems that students are more likely to take the word of their peers, who they believe can relate to them and their potential struggles than encouragement from staff members. If a friend has already sought support from MSS, this conveys a message that it is not seen to be as demeaning to also ask for help.

This importance around not feeling judged and being comfortable with asking for support is also an indicator of why students believe effective advertising by making the MSS tutors familiar to students will be so helpful.

Another factor resulting in non-engagement is a lack of understanding of **sigma**'s role and capacity to help students. Many see the support as remedial and only for struggling students who do not enjoy maths. This again reinforces the belief that students who seek support from MSS are "stupid" and it is therefore an embarrassing thing to do. More effective advertising making clearer the role of MSS (as well as its existence) and that it is not just being for weak students should be done, particularly in courses that have a smaller mathematics component. Students on these courses hear about **sigma** usually at the beginning of their first academic year and in certain courses, may not be reminded of it again. This can be detrimental when the students "suddenly" encounter mathematics in their course and may consider dropping out.

One previously under-researched factor that appears to impact on engagement is the affective dimension, which includes reasons such as being embarrassed to seek support, feeling stupid, etc. Many of these reasons can be connected to students feeling anxious about seeking help from mathematics support, and some responses make it apparent that students may be struggling with MA in particular. It is clear that steps need to be taken to ensure these students, and indeed, any others who may not have wanted to disclose such personal information, feel that MSS is a safe space to seek support where they will not be judged. For the students who do use the service and who display high levels of anxiety, care must be taken that their fears are not reinforced, and this could potentially be achieved through the MR intervention described in Chapter 6.

Whilst the questionnaires did give some insight into student reasons for engagement, it was decided that to maximise the quality of information received, students should be asked to participate in interviews to answer similar questions in more depth. A discussion of the interview responses will follow in the next chapter.

The summary of key findings can be found below.

- Students see MSS as remedial, which may hinder their engagement.
- Current advertising practices could be more effective and detail how MSS is useful and how to access the support. For "anxious" students, having a clear path of how to access support is important since there may also be a "fear of the unknown".
- Advertising practices should be modified to address the affective reasons impacting engagement. Focus should be placed on sharing the ethos of the centre, the non-judgemental nature of the staff, and that the centre helps students of all abilities. This message should be shared across multiple platforms to increase reach.
- When open-ended questions are used, students rarely cite structural reasons for both their engagement and their non-engagement.
- 33% of students overall said affective reasons hindered their engagement; amongst students who had not engaged the level was 37%. This is a high percentage of students that are not engaging due to affective reasons.
- Affective reasons are given for both engagement and non-engagement, indicating that this needs to be considered more when encouraging students to avail of the support.

8 Further exploration of reasons for engagement with MSS: deeper insights from interviews

8.1 Introduction

The engagement questionnaire presented some interesting insights into why students chose to engage or not engage with MSS. Further to these, interviews were conducted with some students to allow them to discuss their engagement further. Thus, this chapter outlines the thematic analysis and discussion of the qualitative findings that emerged from the delivery of semi-structured interviews with Coventry University students.

Engagement with MSS has been of particular interest for many years since many at-risk students do not avail of the support. Structural reasons such as a lack of knowledge of the location or availability of MSS are the most cited reasons for student non-engagement. However, Symonds et al. (2008) suggest that these reasons may be given to hide the true affective reasons for non-engagement, such as embarrassment. This was investigated by Grehan et al. (2016), who found that, amongst 16 students who had either passed or failed first-year mathematics, fear was one factor that influenced student non-engagement. However, the large-scale study by O'Sullivan et al. (2014) reported again that the most common reasons for non-engagement were structural or process reasons.

These findings from the literature suggest that the understanding gained from the quantitative results of this study, discussed in Chapters 4 and 5, paints a partial picture of engagement. This led the researcher first to deliver engagement questionnaires to students at Coventry University and thereafter follow up with interviews to delve deeper into the reasons for engagement. The influence that MA may have had on student engagement and their attitudes around mathematics were of particular interest. In the engagement questionnaire, students were also asked for strategies to increase student engagement with mathematics support, particularly for students with anxiety who have not yet engaged. It was felt that greater value from their ideas could be found here through discussing them further in interviews.

Thus, this chapter focuses on the interviews given by students and proposes to answer RQ4:

RQ4) How do students explain their level of engagement with MSS?

The sub-research questions are:

SRQ1) Does MA affect student engagement?

SRQ2) How do students think sigma can encourage greater student engagement, particularly of MA students?

SRQ3) How does past experience with mathematics affect student engagement with MSS?

This chapter presents the views of students who had engaged with MSS before the interview (including those who engaged regularly and those who have used the services only once) and those who have not accessed the drop-in support at all. An overview of the participants will first be presented before detailing the themes that arose from the interviews around their engagement, their views on both mathematics and mathematics support, and their perceptions of the impact of mathematics anxiety on engagement.

8.2 Data Collection and Analysis

8.2.1 Sample

One hundred and four students responded to the engagement questionnaire, of which 23 agreed to participate in the interviews. The data on their backgrounds are summarised in Table 8.1. Information on student ethnicity was given when this information was available; in the cases it was not, student nationality was given. Course titles have been shortened.

Table 8.1

An overview of the interviewees' backgrounds

Student	Course	Gender	Mature	Ethnicity	Year of Study	Visited	MA	MR
1	Research	Female	Yes	White	PhD	Yes	4.90	2.61
2	Maths	Female	No	Asian	2	Yes	1.90	4.22
3	Research	Female	Yes	Indonesian	PhD	No	NA	NA
4	Maths	Female	Yes	White	2	Yes	2.1	3.96
5	Com Sci	Male	Yes	German	1	Yes	4.1	4.65
6	Research	Female	Yes	White	PhD	Yes	NA	NA
7	Research	Female	Yes	Asian	PhD	Yes	3	3.57
8	Research	Female	Yes	White	PhD	No	1.8	4.57
9	Research	Male	Yes	Black	PhD	No	NA	NA
10	Maths	Female	No	Polish	3	Yes	3.5	3.78
11	Research	Female	Yes	Indonesian	PhD	No	2.9	3.22
12	Maths	Male	Yes	White	3	Yes	3.5	4.09
13	Eng	Female	Yes	Black	1	Yes	1.9	4.70
14	Research	Female	Yes	Asian	PhD	No	4	3.22
15	Psych	Female	Yes	White	4	Yes	3.9	4.13
16	Research	Male	Yes	Jordanian	PhD	Yes	NA	NA
17	Research	Female	Yes	White	PhD	No	NA	NA
18	Research	Female	Yes	Singaporean	PhD	No	3	3.61
19	Research	Female	Yes	Indonesian	PhD	No	3	3.17
20	Research	Female	Yes	Indonesian	PhD	No	NA	NA
21	Biomed	Female	Yes	White	1	Yes	2.9	4.26
22	Research	Female	Yes	Asian	PhD	Yes	NA	NA
23	Eng	Female	No	Black	3	No	2.3	3.96

Students were not pre-selected for the interview based on these characteristics; instead, it was a self-selecting sample and any student who agreed to be interviewed before a predetermined date could participate. As evidenced by Table 8.1, mainly female, mature PhD students participated in the interviews due to difficulties with recruitment during the pandemic. There was a slight skew towards those who had engaged with MSS also opting to be interviewed as expected. However, 10 of the 23 participants were non-users.

8.2.2 Recruiting participants

The engagement questionnaire was open to all Coventry University students. It was advertised on various platforms, including the **sigma** website, in the **sigma** centre, and on the Aula page of multiple courses, to name a few. One question asked whether they would be happy to be further contacted for participation in an interview.

Specifically, students who studied Engineering, Mathematics, Nursing or Computer Science were targeted since the researcher was able to gain access to these courses by curating relationships between **sigma** and course staff. During lecture time, students in these courses were asked to participate. However, the focus of participation was on the questionnaire rather than the interview, as it was believed that students would be more willing to participate in a less time-intensive task.

Students were contacted electronically for participation in the interview, primarily through Microsoft Teams and email, though students were also recruited in person from the University library. There were no responses in 2021, likely due to the impact of the pandemic, and so students continued to be contacted through February 2022. It was hoped that this would give a true depiction of students' anxiety without it being clouded or stressed by the pressure of the upcoming exams. However, students do have regular assignments throughout their academic year. This also meant they had been given some opportunity to have engaged with MSS.

It was initially anticipated that students would participate in focus groups: one with students who had engaged, another with those who had not, and one with a combination of the two to encourage discussion around how to improve engagement. However, due to a relatively slow response to agree to participate, it was decided to switch from focus groups to individual interviews.

8.2.3 Methodology

Thematic analysis (Braun & Clarke, 2006) was used to analyse the interview data, utilising the software tool NVivo. The transcripts were initially generated through Microsoft Teams, after which they were checked for accuracy. These transcripts were inputted into NVivo, where the researcher appropriately coded student responses. These codes were then grouped according to the overarching themes. A second coder was asked to analyse ten randomly chosen interviews so that themes could be checked for accuracy and revised if needed. Analysis by the researcher focused on if any themes emerged from the responses to specific questions (or if students gave an answer that applied to certain questions), whilst the second coder focused on overall themes that emerged from the ten interviews they analysed. The themes matched overall, with the exception of a few. It was agreed in subsequent discussions that this was a result of the second coder having mainly analysed the transcripts of non-engagers, and had the full dataset been analysed; these themes would have emerged. Furthermore, some points mentioned herein have only been mentioned by a few respondents but give some key insight into what may, in the researcher's opinion, hinder some students' engagement. In these cases, it is marked that this was not a theme but an interesting comment made by students that may be seen as an additional code.

Further details of the methodology of the interviews and their analysis can be found in Chapter 3.

8.3 Questions

8.3.1 Why do students engage?

Students who had engaged with MSS gave reasons about what had led them to seek support. Again, students could provide more than one reason for their engagement. Students who had engaged were also asked how others may be encouraged to engage and what might hinder others' engagement, which has been considered within this section, too. The themes can be seen in Table 8.2. Participant totals are not necessarily out of 23 since some students engaged whilst others did not. For example, 13 participants mentioned course help as a reason for their engagement with MSS. However, since not all 23 respondents had engaged with MSS, we should not view this as 13 out of 23. Students also typically gave more than one reason for their engagement, such as course help and fear of failure.

Table 8.2

Common themes of why students choose to engage with MSS

Theme	Illustrative Quote	Participants
Course help	*"I think it was mostly like a pattern, so I do the… so like every time like exams would come around, I would do the tutorial sheets, highlight the questions which I'm stuck on and then go there."*	*13*
Staff	*"Mostly, because, like, if my teacher would explain something and I don't understand how he explained it, then I would go to* ***sigma – sigma,*** *so that they could explain it and then they usually explain a bit differently then, that makes you understand."*	*9*
Personality – resilience	*"In my case, if I fail, I will keep trying until some point… because if you stop, you will fail. I mean, that's it."*	7
Personality – help-seeking	*"I'm not afraid to ask questions in general."*	5
Social factors	*"I went with my friend, so it was less. I think it's not as bad when you go with someone else, 'cause it's, it's just like shared. So like if you both don't know something, then you feel less bad about it."*	*4*

8.3.1.1 Course help

As expected, the reason students most gave for seeking support from MSS was to receive help with understanding course content. This includes students who engaged specifically for assessment/exam support. Nevertheless, as in the case of non-engagement, with students initially citing process factors as their reason and then following it with another more in-depth reason, students here went on to speak about other reasons for their engagement. Since course help was mentioned so often, it was kept as a theme with this disclaimer attached.

Respondent 12:

"I think it was mostly like a pattern, so I do the… so like every time like exams would come around, I would do the tutorial sheets, highlight the questions which I'm stuck on and then go there."

There was a consensus that the help given had been sufficient, though one student was surprised at the level of help received because it was less support than they expected. This meant that they did not visit MSS again for the support, although there were many other reasons for this, including finding additional support through their supervisors.

Respondent 1:

"I still sort of had to figure it out for myself, and maybe that's why I just was like, oh well, I'll figure it out using textbooks then. Because I'll have to figure it out anyway, and I do need to sort of know this and figure this out."

This student later admitted their perception of **sigma** had been skewed, and they now understood the nature of the support provided. Although they had not been back to the centre since their first trip, they have said they would return for help now that there is a stronger need for statistics in their research.

Respondent 1:

"I think now I see that it is more of something that's there to aid you in getting to that end result. It's not there to give you that end result."

While **sigma** always aims to help all students with the content of their courses, there is a misconception that it is there to give you the answer. Respondent 1 had learnt that MSS is available to help students understand the content, not to do the work for them, which they were unaware of.

8.3.1.2 Fear of failing

As a student who had not engaged with MSS succinctly summarised, seeking support was the *"lesser of two evils"* (Respondent 9) when students were concerned about failing. Comparing seeking support to an "evil" was particularly evocative. The exchange between the interviewer and Respondent 9 has been added below for clarity:

Interviewer:

"What do you think is the relationship between maths and stats anxiety and not engaging with ***sigma****?"*

Respondent 9:

"Well, I think it's pretty obvious. If you feel anxious about maths, why would you go to [sic] in maths and stats centre?"

Interviewer:

"What about if you needed to do well on maths and stats to do well in your course?"

Respondent 9:

"OK, then yeah, you probably would be then, it would be like being in a situation where you had no choice, so we choose the lesser of two evils."

Students tended to ask for help when there were impending deadlines; it is generally not as common for students to continually seek support through the year when there are no regular deadlines. The centre is considerably busier around exam periods and submission deadlines.

Respondent 6:

"I think it was, it was [sic] *without getting to, you know, being too dramatic about it, was sort of hitting rock bottom. And knowing I needed that support. So, I was finding that, actually, the stress of it was really impacting my mental health and that I did need to - I, I did need to seek that support."*

What is of interest is that some students felt they had to hit the point of no return before they sought support. Despite knowing that they were struggling with their course content significantly, some students only visited MSS when they were desperate, even when their struggle also impacted their health.

Respondent 1:

"Yeah, I feel like that fear of failing sort of outweighed me feeling like an idiot 'cause I was just there a bit like. Well, I'd rather go like an idiot and not fail than not go and fail and look like an idiot anyway."

Here, the student again was prompted to seek support because their fear of failure won out over their fear of embarrassment. It seems that for some students that are extrinsically motivated, fear of failing their course generates sufficient motivation to override other affective reasons for not engaging.

It should be noted that many of these students regard seeking support as something that is an undesirable thing to do. In the most extreme case, it is regarded as an "evil". However, some things are even more undesirable (such as failing their course) that can overcome their reluctance to seek support. This is consistent with the findings reported in Table 7.13, which showed that engaging with MSS was an unpopular support activity. However, doing nothing (which would probably lead to failure) was even more unpopular.

8.3.1.3 Impact of social factors

Whilst only four students discussed how social factors encouraged their engagement, there is evidence that knowing others who have used MSS services can encourage students to engage with MSS, which is highlighted throughout this thesis. This can lead to MSS centres becoming social learning spaces (Solomon et al., 2010; MacGillivray, 2009). A recent unpublished undergraduate project at Coventry University (Duncan, 2022) also found that many students reported finding it easier to come to MSS for the first time with a friend than on their own. Therefore, it was decided that this would remain a theme, especially since some of the students within the sample had only used online support, where social factors could not have been a factor.

Respondent 2:

"One of my friends like used to use it with me in first year, so we used to go together to the sessions."

Respondent 12:

"I went with my friend, so it was less. I think it's not as bad when you go with someone else, 'cause it's, it's just like shared. So like if you both don't know something, then you feel less bad about it."

Respondents 2 and 12 were both mathematics students who are known to use the space in this way (Solomon et al., 2010).

Respondent 6:

"I think without probably my, my, my [sic] *friend just saying to me on several occasions to get that [support], I probably wouldn't have, Oh, you know, been so quick to go, really."*

8.3.1.4 Staff

The "Staff" theme covers two main ideas: different teaching methods and reassurance.

Students found that the different approaches to teaching taken by staff in MSS incentivised them to visit **sigma**. The MSS services gave them another clear source of support when explanations by their lecturer were insufficient.

Respondent 2:

"Mostly, because, like if my teacher would explain something and I don't understand how he explained it, then I would go to ***sigma – sigma,*** *so that they could explain it and then they usually explain a bit differently then, that makes you understand."*

Students found that the simple language used by staff also helped.

Respondent 22:

"Sometimes when you're too close to a subject, you don't necess- you explain it like you know it, but not necessarily using simple language in terms of the way, you know, someone who's asking you questions about it, um, so I found that certain people I prefer to go to because I know they can explain it in a way I will be able fully understand it."

The familiarity of certain members of staff also encouraged them to engage rather than seek support through other means, such as Google.

Respondent 19:

"I prefer to find something that is already… I know [MSS tutor name]*, so rather than Googling… the familiarity, yeah."*

Other students referred to staff in terms of them providing reassurance. Some students use the centre to seek reassurance that their work is correct, which is closely related to the theme of "course help". However, this was added to the "staff" theme since it appeared that students came to **sigma** staff for reassurance because of their confidence in the staff personally rather than because **sigma** is available for such questions.

Respondent 5:

"I met a really nice maths teacher… and he was really helpful not just with my maths. He also gave me confidence that I'm able to pass the module."

Respondent 6:

"When it's been written up and getting that kind of guidance as well, it is really helpful, and also talk about, you know, calming down, getting reassurance."

The ethos of MSS is to address the student's concerns, with most interactions being on a one-to-one basis. This enables the staff in MSS to take different approaches from those in regular lectures and tutorials. MSS staff are not required to "cover the syllabus", so they can spend more time "giving confidence", "calming [students] down", and providing reassurance. Students may also feel more comfortable with MSS staff since they are not involved in the summative assessment of the students. This may give students an additional sense of freedom in opening up about their mathematical difficulties. Students value the "affective" support that MSS staff can provide them with.

8.3.1.5 Personality

Personality appeared to affect students' willingness to seek support and their attitudes towards mathematics. The (overall) resilience and help-seeking facets of their personality seemed to determine this most.

Respondent 1:

"I think I'm just someone that will [ask for help] *if I'm stuck, I just always ask for help. So even like all my lectures, like a lot of people, they've never messaged the lecturers. But I'm - as soon as I get stuck, I always make sure I just message them."*

Respondent 5:

"I'm not afraid to ask questions in general."

A student also highlighted the relationship they believed existed between MA and personality, which was reminiscent of the relationship between MA and MR, as discussed in Chapter 4.

Respondent 1:

"I think for most people it [MA] *would be a hindrance potentially, but then I think you will get the small group of people that are like, well, I'm somewhat anxious about this, so I'm gonna do something about it. So I think maybe it's gonna depend on personality."*

Again, it appeared that, for some students, this fear of failure and whether or not it overrode fear of engagement and embarrassment was crucial to understanding their engagement (or non-engagement). Another student that had engaged spoke of their fear of failure in relation to their personality, showing the interrelatedness of all these themes.

Respondent 6:

"And it was kind of accepting that and going I need help. And knowing that my questions would probably be incredibly basic and incredibly silly and kind of getting over that."

Respondent 16:

"In my case, if I fail, I will keep trying until some point… because if you stop, you will fail. I mean, that's it."

Students also mentioned several times that with the drop-in centre, they were mindful of other students in the centre. Whilst the centre usually does have sufficient capacity for the number of students visiting, during the exam period, it can get very busy. This may deter some students from seeking support. For others, it was the reason why they preferred booked appointments.

Respondent 22:

"I'm always conscious that when you go and you drop-in that they only, they're, they're aware that they can only spend so much time with you because if someone else comes along and, and I appreciate that and I understand that…. I feel because of the drop -n session, you might feel that, Oh no, you're taking too much of their time, they need to move on to the next. So you could then feel a bit bad if you've had that kind of experience where there's been a lot of people at one time. So that also might put them [other students] off."

8.3.1.6 Summary

Whilst structural reasons have been claimed to be a mask for affective reasons of non-engagement, it seems as though there are also affective reasons underlying why students engage, too, particularly when students mention engaging for "course help". Many students first spoke of accessing the support to receive course help, before discussing factors such as having "hit rock bottom" or wanting different teaching methods from tutors that were "patient" with their learning. This gives some explanation to why some students who know they need course help engage, but others do not. Some students also spoke about needing course help for themselves, but when asked why others might not engage, spoke of factors like embarrassment.

8.3.2 Why do students not engage?

Analysis of the interviews revealed students attribute their level of engagement with **sigma** to several factors. It must be noted that students may have given multiple reasons to explain their level of engagement. Some students had engaged with MSS, but either chose consciously to not re-engage or had not yet needed to seek help again. Their responses were also considered here. Responses around what may hinder others' engagement were also included.

The overall themes for this question's responses can be found in the following Table 8.3, which is then followed by a more detailed discussion of each theme.

Table 8.3

Common themes of why students choose to not engage with MSS

Theme	Illustrative quote	Number of students
Affective reasons - Year of study	*"I think there is a little stigma around asking for help with the easiest stuff in 3rd year."*	*13*
Affective reasons	*"A lot of my friends are in general scared to ask questions because they always think that their knowledge is not good enough, and they just, just think maybe the teacher will think them too stupid. Well, they're in general afraid to ask stupid questions."*	*12*
External support	*"If I really need help, then yeah (I would use* ***sigma****), but I would rather go to my colleagues first. I feel more comfortable asking them for help."*	*11*

8.3.2.1 External support

External support was the most mentioned reason for not engaging with **sigma**. Interestingly, one student mentioned time constraints as their reason for not engaging (*"in **sigma**, I have to follow certain times")*, and why they would rather use external support, such as their colleagues because this support was available more often. However, when they were asked to elaborate, it was evident that seeking external support was mostly a matter of comfort. Another student, Respondent 20, said external support was the reason for their non-engagement, then, later in the interview, spoke about their anxiety around the language barrier and how they were scared to use mathematics in their research project. It is evident that whilst students initially gave the "shallow" reason for their non-engagement being seeking external support, there were deeper affective motivators impacting their decision to not engage.

When asked why some students engaged and others did not, Respondent 11 replied,

"Sometimes we need… not moral support. Personal support. A personal support outside the sigma. So maybe… we feel more comfortable talking with them or discussing with them than with sigma… In Indonesian culture, we tend to feel a little bit hesitant if we… think that people with [will] think us [sic] *not to understand clearly."*

This sentiment was mirrored by others.

Respondent 13:

"If I really need help, then yeah (I would use ***sigma****), but I [would] rather go to my colleagues first. I feel more comfortable asking them for help."*

The pandemic also prompted students who had previously engaged with the centre to now seek support elsewhere.

Respondent 23:

"I think since (the pandemic), we started relying on each other rather than going to the centre."

8.3.2.2 Affective reasons

As mentioned in Chapter 7, the lack of knowledge of what happens in **sigma** hinders engagement in that the fear of the unknown, in that case, is stopping them from engaging. The interviews provided further evidence of this, especially since there was also a fear of being judged by staff and by other students. Many students displayed this fear in relation to various aspects of their engagement. Thus, different types of fear were displayed by students who had not engaged: fear of judgement and fear of the unknown. Fear of judgement includes students not wanting to be embarrassed or displaying a lack of knowledge because they were afraid of looking stupid in front of staff members or other students. Fear of the unknown includes students not knowing enough about MSS, which for many, led to a fear of judgement because there was an assumption that they would appear stupid when asking for help.

Respondent 9:

"I think if staff there were welcoming and non-judgmental and patient because I imagine how I would probably be annoying."

This is clearly a perception issue and not an experience one. Students may think asking questions is showing a lack of knowledge, which they are not comfortable with. There is a clear fear of judgement from staff.

When students who had not engaged were asked what would encourage others to do so, many raised this point. This is another area where there is clearly a communication gap. Staff working in **sigma** regularly receive feedback from students thanking them for their patience and non-judgemental attitudes. Comments such as, "[MSS tutor name] *was lovely and kind, even though I came with a lot of problems*" are commonplace. It is not so much fear of the unknown but the unknown itself (i.e., students not knowing what tutors are actually like) that is keeping some of them from engaging.

Respondent 6:

"I think it is a fear of looking stupid. Uhm, you know, that was probably the big thing for me… and it was kind of accepting that and going I need help. And knowing that my questions would be incredibly basic and incredibly silly and kind of getting over that. So, I think it can be … sort of a fear of embarrassment."

Despite the efforts from **sigma** to show the usefulness of MSS to all students, regardless of ability, students appear to have internalised the idea that seeking support is only for struggling students. Even if a student is struggling, the fear of others thinking of them as a struggling student prevents them from seeking the help they need.

Respondent 5:

"A lot of my friends are in general scared to ask questions because they always think that that their knowledge is not good enough, and they just, just think maybe the teacher will think them too stupid. Well, they're in general afraid to ask stupid questions."

Asking for help is seen as unsafe, and this fear may be borne from the relationship students have with their lecturers or other teachers (past or present). An interesting note is that some students attributed the fear of embarrassment as a cause of lack of engagement to a friend but said they personally did not feel like it would be a barrier to their engagement. This may be because students are not comfortable with expressing their own emotional discomfort, but it also highlights that those who were not interviewed may potentially also face this barrier.

Respondent 17:

"A lot of the anxiety comes from again, embarrassment. I think they feel they don't…a lot of students feel that the questions they, or the things that they don't understand, that they're gonna seem stupid for not knowing how to do it, so I think the more anxious a student is, the less likely they are going to use support because not only are they anxious about actually doing the maths and not being able to do the maths, they've then got to admit that to themselves and then admit that to other people. And so I think that adds another level of anxiety on top of it."

This student had not engaged with MSS and gave the reason for it not being necessary for them as their supervisors were mostly able to answer their questions. They also said they occasionally searched online for support and were accustomed to this as their previous university had not offered MSS. However, they also were open about their mathematics background and weakness in statistics that they were uncomfortable with sharing since they were expected to be good at statistics.

Year of study

Students had opposing views whether or not asking for help became more difficult as they progressed through university. The majority stated that being in later years made it harder to seek support. Seeking support with familiar or "easy" topics is regarded as almost taboo, particularly since they are in university, and if they have already advanced to their third-year. Students are potentially suffering from some level of imposter syndrome (Bhosale, 2022) and believe that reaching their third year means they should not have any gaps in their knowledge. They may feel as though admitting they need help proves they do not belong.

Respondent 12:

"I think there is a little stigma around asking for help with the easiest stuff in 3rd year."

Respondent 13:

"They could have the (mis)conception that, oh, you've made it to 3rd year. You should know this material. Why come in and ask for help?"

Respondent 17:

"But I think there's, there's an, there's an [sic] *air of expectation by the time you reach your third year that you should actually be knowing what you're doing."*

Students display a clear fear of looking stupid if they are asking for help with the "basics" in their third year.

Respondent 15:

"So if you if you in year three still needed some support, then I don't think… it's still a learning process. So I don't think it would be make any difference. Not to me. Anyway, I don't know what the lecturers would say... the only thing I would think is lecturers wouldn't share my point of view, I don't think."

The highest number of visits to **sigma** are from first-year students, with much fewer visits from second-year students. The number of visits slightly increases again in third year when students seek help with their final year projects. The reduction in the proportion engaging after the first year could potentially be explained by this belief that students should know all the material from previous classes without the need for revisiting. However, there is also the issue that as students progress through their university degree, the material becomes more specialised, and so it may be more natural for module lecturers to be approached for support instead of MSS tutors, who may not have the specialised knowledge. It may also be due to the fact that many students only have a maths/stats module in their first year.

Simply put, for many of these students, they believe there is an expectation that they should have a certain level of knowledge by their third year, and if they do seek help, they will show an absence of this knowledge and thus look stupid.

8.3.2.3 Other reasons

This subsection discusses various points that were raised during the interviews that warrant further investigation, mainly because they were not mentioned enough times to be classed as a theme, or because these codes were mainly given as reasons for why others may not engage, but the students that gave this reason had actually engaged. These additional codes are summarised in the following table.

Table 8.4

Common codes for why students do not engage

Code	Illustrative quote	Participants
Not needed	*"I think I would describe myself as having a kind of relatively higher knowledge of stats, then perhaps the average first-year PhD student."*	6
Personality and motivation	*"I think most of them are aware there is Sigma, but I think they have to do the first step, they have just to go there and this is hard to encourage them. You can't force them to go there."*	4
Process factors	*"From the time wise, uh, I can, I can ask my colleagues anytime. But in **Sigma** I have to. I mean I have to follow certain times, maybe I don't know."*	4
Age	*"Another worry I sort of had when I went in at undergrad. That would be, I feel like it wouldn't be there as much now, was that I was like I don't know what I'm doing, so I don't know who to go to. I think I'm a little bit more confident now I'm a bit older and I don't know if that's just from experience or maybe I care less as I've got a bit older and maybe I'm a little less embarrassed if you know what I mean like I've got, I'm a little less ashamed if I can't do it because I've kind of come to accept that I've never been really good at maths."*	2

Process factors

Process factors have been identified as a code since some students initially gave this reason for their non-engagement. However, as the interview progressed, other reasons for their non-engagement were disclosed, such as embarrassment.

However, in this study, some participants have said they felt it was inconvenient to access support due to the timings. When they were informed by the researcher of the extensive opening hours of **sigma**, many were surprised and admitted they had not known the times when the centre was open nor the fact that an appointment was not necessary. Nonetheless, students preferred asking friends for help because this was something that could be done at any point of the day.

Respondent 11:

*"From the time wise, uh, I can, I can ask my colleagues anytime. But in **Sigma** I have to. I mean I have to follow certain times, maybe I don't know."*

The concept of drop-in support was also unfamiliar to some, particularly online support.

Interviewer:

*"Did you know that **sigma** is also available online? We offer support online as well."*

Respondent 20:

"I didn't know. And it is, it, like uh through online, like on teams or an email or what is it?"

Although it appears that many students are aware of the existence of MSS, the reality seems to be that a considerable number of them have very little knowledge about the nature of the service provided or when it can be accessed.

Age

Age seemed to impact the possibility of feeling embarrassed and seeking support, too, though it was only mentioned by two students. However, the author believes that should a similar analysis be run with more participants, more would emerge around this, particularly since year of study (discussed in Section 8.3.2.1) may have been related to this code.

Respondent 1:

"Another worry I sort of had when I went in at undergrad. That would be, I feel like it wouldn't be there as much now, was that I was like I don't know what I'm doing, so I don't know who to go to. I think I'm a little bit more confident now I'm a bit older and I don't know if that's just from experience or maybe I care less as I've got a bit older and maybe I'm a little less embarrassed if you know what I mean like I've got, I'm a little less ashamed if I can't do it because I've kind of come to accept that I've never been really good at maths."

This student felt it was easier to ask for support as they aged because it was easier to not be embarrassed when they had already come to terms with their ability in maths. However, it was unfortunate that it was only because this belief of being bad at maths was cemented in their brain that they grew comfortable with asking for help.

Personality and motivation

Just as students identified personality as a theme about why students engage, this along with motivation also emerged as a code about why they do not engage. Students identified having a resilient personality as one of the factors that affected student engagement. As noted in 8.2.5, where students have a resilient personality, then they are likely to engage. It therefore follows, that not having a resilient personality, is likely to mean they do not engage.

Respondent 5:

"I think most of them are aware there is ***sigma****, but I think they have to do the first step, they have just to go there and this is hard to encourage them. You can't force them to go there."*

Students identified others who had not engaged as delaying seeking support until just before their exams. This may be due to a lack of motivation and interest in engaging with mathematics, and potentially a result of maths anxiety, also. This lack of interest means students may have low levels of intrinsic motivation, where people are driven to complete an action because of internal satisfaction. Extrinsic motivation, on the other hand, relates to being pressured into acting because of a reward, or fear. In this case, many students appear to be extrinsically motivated by the worry of failing their exams (or the reward of passing them). However, this fear of not doing well means many students fail to seek support in time to see the benefits in their results.

Respondent 5:

"I think the biggest problem is most of the students, they don't study in advance that they start to study for exam like two days before and then maybe there's no time. It is as well. Most of the students I know they have timing questions and they just, yeah, they don't start it

during the weeks. The new material they just try to study everything at the end, and then they have, yeah, then there's just no time left to use support."

Students also seem to ignore the fact that they need the help, choosing to spend their time on focusing elsewhere. Again, this act of procrastination may be linked to maths anxiety, but it also might be a standalone factor of someone's personality. Respondent 8 did not profess themselves to be maths anxious, and yet, they admitted to delaying seeking support. Students not seeking support yet being in need of it has been seen many times before in **sigma** (Hodds, 2017).

Respondent 8:

"Time, probably for me, I, I [sic] *sort of like, don't go to things because I just think I've not got enough time or have to prioritise or put it off, put my head in the sand."*

Not needed

Some students mentioned not having needed the support (yet). For some, it was evident that this was due to the nature of their course, such as if they were doing qualitative research in the current stage of their research. For others, it was because they felt they were competent enough in mathematics/statistics to not need the support, but stated they would go if it was necessary.

Respondent 18:

"I think I would describe myself as having a kind of relatively higher knowledge of stats, then perhaps the average first-year PhD student."

In either case, it is clear that the students were aware of their competency in mathematics, and whether their course required mathematics that they may need support with.

The idea that some students do not need mathematics or statistics support is consistent with previous work such as that of O'Sullivan et al. (2014) which identified three groups of students: those that have come for support, those that have not come for support and do not need it and those who have not been for support but would benefit from it. From the three students that mentioned they did not yet need support and had not yet used it, it appears they would fit into the second category mentioned here. The other three students that discussed this had used the support and cited this as a reason for why others may not engage.

Staff

As described in 8.2.4 above, staff were identified as a theme in the reasons for engagement. Few students mentioned staff in their reflections on reasons for non-engagement when mentioning other reasons, and staff did not emerge as a theme or a code in relation to non-engagement. Nonetheless, it is worth recording some of the few comments were made about staff in this regard.

Some students felt having lecturers or student proctors that they recognised in the centre was a deterrent to their engagement, although it is worth noting that some of these students had in fact engaged with **sigma** and discussed this when speaking about others' engagement. Comments made by students included them worrying that lecturers would not want to support them in coursework-related content or that proctors and/or MSS staff may not be able to support them/may make them feel less assured because they did not know the course material as seen in the example below:

Respondent 12:

*"I know if you need help with coursework you shouldn't go to the **sigma** support centre. But then if you need help on that topic I guess. But if your lecturers are in there then they might just turn around say well no, but even if it's not coursework, but it's like the topic of the coursework."*

Respondent 23:

"I also did realise back in first year at times when, when the maths got a bit too engineering based, they weren't really able to help so. I just thought they probably wouldn't be able to."

Lecturing staff being available in the centre was deemed to be both a pro and a con since some found it beneficial that staff knew the course content well (which was feedback given from students who had engaged), whereas others were less motivated to seek support as they believed there would be judgement, particularly around asking for help on coursework content.

Having staff from the Health and Life Sciences Faculty ensures that **sigma** is visible to students studying those courses since many students have claimed that **sigma** is not a place for their specific mathematics needs. In fact, Hodds (2020c) found that one of the things that encouraged more nursing students to come to the centre was having some nursing lecturers do their office hours in the centre. One student mentioned having staff from biosciences in the centre might also increase engagement from bioscience students, whilst an engineering student spoke about the benefits of having engineering proctors in the centre.

It appears some students had let previous negative experiences (outside **sigma)** of asking staff for help cloud their perception of support staff at **sigma**.

Respondent 12:

"So, I feel like asking for help. It's a, it can be seen as kind of a bad, sometimes, I don't, well, not bad thing, but that they think they should know it. And that asking is going to be like, they're gonna - they might get response like, well, you should know this by now. Why didn't you know this?"

The comments above suggest that students feel they cannot ask for help with 'easy' maths, and therefore, avoid coming to the centre. The researcher ensured that all students were told of the non-judgmental nature of the staff and of the wide variety of mathematical content that they could be helped with.

8.3.2.4 Summary

Many different causes for non-engagement have been determined through the analysis of the interviews. The students' perceptions of **sigma** are the biggest factor affecting the likelihood of students using the support available since many students first responded with a structural reason before going on to specify an affective one; this indicates that for many, they are embarrassed about seeking support with the centre for fear of what it might mean. There were also some indications that MA might be a factor contributing to non-engagement with MSS. This was further reinforced since students repeatedly spoke about the importance of non-judgemental staff.

8.4 Overall themes

8.4.1 The Impact of the Covid-19 Pandemic

Students have indicated that they prefer to seek help from their peers rather than from MSS, because of issues of familiarity and trust with their peers. The pandemic may have further reinforced this. The closure of the physical drop-in centre and the consequent large reduction in engagement with MSS during the pandemic has meant that students became even more used to *"relying on each other"* (Respondent 23) making them less likely, post-pandemic, to visit the in-person drop-in centre. Students who had used the centre as a social learning space for work had to readjust since the centre was temporarily closed. Even when it initially reopened, students only used the space when help was needed as social distancing rules were being enforced.

Respondent 13:

“I used it a lot pre-Covid… I don't think it's anything to do with, the, with a well, well, with the illness itself. But it's so 'cause… I don't, I wouldn't really mind if I got it. It's more to do with the fact that it's, everything's been shut for so long that it's just feels normal not to go.”

When asked if their peers used **sigma**, Respondent 23 indicated that they used to, and had then stopped.

Respondent 23:

“Not anymore… I think probably because of the pandemic because we did use it a lot in first year, but I think since we started relying on each other more than going to the centre.”

For students that had not engaged, it appears that social support has meant they seek help outside of **sigma**. Others found that the pandemic had not disrupted their usual patterns of help-seeking because of the alternative support **sigma** had in place, such as the online support.

Respondent 13:

“I don't think COVID affected me that much 'cause help was always available.”

Interviewer:

“And is that including the online support at ***sigma*** *as well?”*

Respondent 13:

“Yes.”

Respondent 6:

“So I've gone to some of the workshops that had were delivered online during the pandemic, but I also went to some of the physical workshops prior to that.”

Respondent 1:

“I'd say it's quite nice that to… know that you've all gone online as well with the pandemic.”

The online support had an additional perk in that students were given a certain level of anonymity since cameras are generally not turned on for online support and some students may feel more comfortable with this, which was specified by Respondent 20 only and so was not a noted theme, but an additional point.

Respondent 20:

"I think, uh, it [online support] *could make me, uh, more comfortable* [because you don't need to show your face]."

However, particularly in the case where there is a language barrier, this student felt the camera being on might would make communication clearer.

8.4.2 Mathematics anxiety

Findings in Chapter 5 (Figure 5.1) suggest that aside from students with low levels of MA and MR, MA, MR and student engagement in CU appear to follow certain patterns; students with medium MA and high MR engage most often, with some nuances. For students with high MR, the relationship is like the modified Yerkes-Dodson curve (Nickerson, 2023) described by Wang et al. (2015), whilst for those with medium levels of MR, engagement with **sigma** appears to monotonically increase as MA increases.

Based on this, some level of anxiety is conducive to good performance in those students that are motivated to do well; however, for some, high levels of anxiety can hinder performance.

Indeed, Respondent 12 described it as such:

"I think it depends on the level of anxiety. If they're not very anxious, then they'll probably just kind of go at it alone, whereas I think someone with more anxiety around the subject to seek out help."

Interviewer:

"What do you think is a relationship between maths and stats anxiety and not engaging with ***sigma****?"*

Respondent 9:

"Well, I think it's pretty obvious. If you feel anxious about maths, why would you go to in maths and stats centre?"

Interviewer:

"What about if you needed to do well on maths and stats to do well in your course?"

Respondent 9:

"OK, then yeah, you probably would be then, it would be like. Being in a situation where you had no choice. So we choose the lesser of two evils."

The above seemed particularly eye-opening as they not only likened not doing well on their course as an evil, but also seeking support from MSS. This shows the overlap of state and trait anxiety with MA, which the respondent believed themselves to have. The interplay of the two for this student meant they struggled to seek support despite having self-professed *"little to no maths skills, aside from the basics"*. However, they further stated they would seek support if needed by asking a friend they believed to be non-judgemental and kind, further reiterating this need for a safe environment to ask for help, and therefore students need to know that **sigma** is a safe place for them, if they are to engage with MSS.

It is also noteworthy that students seem to let this anxiety deter them from seeking support with mathematics, but it does not seem like that is the case for other subjects they are struggling with.

Interviewer:

"And do you feel like this about other subjects that you perceive yourself as struggling with, or would you say it's just maths?"

Respondent 15:

"Uhm. It's interesting you ask that I've never, I've never thought about that. I think it is just maths mainly. With other subjects I don't, I don't feel like, Yeah, with other subjects, I don't feel like I, I, I, [sic] *get that much anxiety. I try and figure it out or I will get that help. Whereas with maths I feel like, OK, if there's an option to avoid it, then I would."*

Interviewer:

"When you said that you have this immediate anxiety around school, so when you describe your anxiety around maths or stats, would you say that's a generalized anxiety around any subject or would you say it's specific to the maths and stats?"

Respondent 19:

"I would say it's specific to math and stats."

Interviewer:

"So you don't feel like that with any of your other subjects?"

Respondent 19:

"No."

It also bears noting that students do not just attribute their MA to their performance in it.

Respondent 15:

"Even though I did OK, it was just kind of like no way would I study it further. And so there's, other than the fact that I did, I did OK and I could have pursued it in A levels or further than that. There was some kind of, there's something else that kind of made me feel anxious about even considering that."

When asked to elaborate further, the student spoke about the culture around mathematics in the English education system. Their attitudes around maths also seemed to be a direct consequence of the attitudes they faced around them. These all revolve around their perceived innate difficulty of mathematics.

Respondent 15:

"Uhm, again I think it's the way that people speak about maths, or generally there's this thing. Maths is hard and we actually had something in our… I taught at a secondary school prior to what I'm doing now and we actually… I can't remember what we had, but we specifically would not talk about how maths is hard and we would encourage the students not to talk about how maths is hard because this was a common thing that you'd hear across students generally when maths is mentioned, they would say maths is difficult or maths is hard and that was a bit… we tried to change that."

Although Respondent 15 had helped students tackle this belief that mathematics is a naturally difficult subject, they had fallen into the same pitfall and had internalised this belief, which may be a reflection of the culture in the UK around mathematics.

8.4.3 Student beliefs about mathematics

There was an interplay of these factors and an effect from student background. Where relevant, students were also asked if they thought culture had an impact on student beliefs of mathematics since it had been raised during the first few interviews.

8.4.3.1 Culture

Students from varying Asian backgrounds commented on how children are encouraged to pursue careers in the sciences, particularly mathematics. Mathematics is seen as a central subject to success; students that want to pursue different (non-scientific) careers are often persuaded to take up STEM courses instead.

Respondent 14:

"Generally in Asian communities it's a… um, Asians are usually kind of encouraged to take up sciences."

Respondent 3:

"In Indonesia like every parents like see that mathematics is really important subject and they are expecting that their, their, their son or daughter will be get a high score in mathematics. So they have a big expectation actually."

Respondent 20:

"Especially in my country [Indonesia], Uh, yeah, seeing the math is a very, very – how can I - very scary subject. Most of the students think that. But like what you see, the culture, I think that the culture affect the way of looking at the math. But uh the culture means here, [sic] if the family, uh build the culture, the good culture, study culture in the in the, in the family environment, I think that's the key."

Many students from ethnically diverse backgrounds commented on the culture of mathematics being seen as difficult and the attitudes of their parents and friends to mathematics. Some students had the preconceived notion that certain cultures were better at mathematics than others or that specific cultures collectively attributed higher importance to mathematics, such as the Indonesian community. There is evidence that this does, in fact, not only contribute to students' attitudes to mathematics but also their willingness to seek support from MSS, as evidenced from the following quote.

Respondent 11:

"Within Indonesian education before, uh yeah, the process they want to get help, but they don't want to get through the, the [sic] at the perception of them being stupid."

In other Asian communities, students clearly recollected their parents' belief of the difficulty of mathematics and how they themselves were anxious around the subject. Therefore, it may be that it is not the overall culture of the country towards mathematics that matters, but rather the culture and beliefs of those around you. For example, in the UK, where MA is more prevalent than in many other countries (Cuemath, 2021) and where there appears to be a culture of pride in being bad at mathematics (du Sautoy, 2016), this may stem from the fact that only a fifth of the working-age population has the numeracy level equivalent to a GSCE pass (Ellicock, 2019).

Respondent 2:

"I like meet people now and tell them that I'm doing maths and the basic general reaction is always like, why on Earth are you doing math."

Respondent 13:

"When people ask me what course are doing, I say maths. Everyone always makes like a groaning sound."

Respondent 2 was an Asian female whilst Respondent 12 was a white male, showing that this may be a universal pattern.

8.4.3.2 Difficulty

Most students also spoke of the perceived difficulty of mathematics, including those that had chosen to do a mathematics degree.

Respondent 12:

"So kind of gives you a sense of kind of like pride like, yeah, I can, I'm doing this course. Everyone thinks it's difficult, kind of thing."

This perception of the difficulty of mathematics also appeared to be related with the perception of its usefulness. Some respondents commented on its central importance to the teaching in their country and how this actually contributed to their fear of the subject because their competence in this subject determined what they would be allowed to study.

Respondent 16:

"This subject might determine their future at the end. So it's also, yeah, it's, that's [sic], *why it maybe, it could be stressful for them with mathematics, it's the future holding this in this account. You can't, you can't study this because if I fail in mathematics, some students say, OK, I can't study medicine, I can't study engineering."*

This was further reinforced even when students could not see the value of the mathematics they are doing, particularly if they did not know why mathematics was important to their chosen career.

Respondent 11:

"The purpose is not synchronised with the doctoral degree, I think that's probably changed the way I see math, uh. From interesting – become not so quite interesting."

Some students also admitted to selecting their degree specifically to avoid mathematics, and some even spoke about how, despite choosing to pursue self-directed study and knowing the value quantitative analysis would bring to their research outputs, they avoided going down this route.

Respondent 9:

"I think if, if the PhD had an element where I would have to solve maths equations, then I probably wouldn't choose it."

8.4.3.3 Perception of ability

A common theme amongst most students, irrespective of whether they had engaged, was the negative perception of their mathematics ability, with this being mentioned by most of the interviewees.

Respondent 9:

"It looked like the whole world knew maths and I didn't."

For those that had not engaged, it seems this also had some bearing on their likelihood of visiting the centre although it was not directly given as a reason for their non-engagement. Despite believing themselves to have little ability in maths, this was a hindrance to them asking for help as they had concerns about their apparent lack of ability being an influencing factor in how staff would view them.

Respondent 1:

"I've kind of come to accept that I've never been really good at maths. No one in my family is really good at math."

8.4.4 Perception of sigma

As in Chapter 7, it is evident that a skewed perception of **sigma** is affecting engagement. For many students, particularly those who have not engaged, there is a concern about staff and other students being judgemental about their mathematical ability. Despite students showing some understanding of **sigma** being an aid to all students when asked directly who **sigma** is for when they speak of their own engagement, they are quick to speak of their difficulties and embarrassment and are unable to apply the consideration they extend to other students to themselves. One student even described **sigma** as a place to "*face your fears with maths in a good way*" (Respondent 21), and this negative attitude towards mathematics, in general, is prevalent throughout the interviews. Another student spoke of how the perspective students have of **sigma** as remedial support may also hinder students from engaging.

Respondent 1:

"If I have to go, it's cause I'm thick as well, like people are gonna think that."

This student had initially said they engaged with **sigma** for course help before they spoke of how this embarrassment and fear of looking stupid could hinder engagement, so again, this is another example that shows how “simple” answers can conceal some of the emotional motivators for engagement and non-engagement.

8.4.5 Advertising

When students were asked how other students may be encouraged to engage with MSS services, many spoke about using advertising to achieve this aim. Students also commended **sigma**’s current advertising strategies and spoke of how they had first been introduced to the support available. Using student testimonials, social media, and advertising through recognised people were mentioned as good examples. There seemed to be a particular focus placed on ensuring students knew the centre was manned by non-judgemental and understanding staff. Although some students were aware of **sigma**’s aim to be non-judgemental and to provide understanding staff, it is clear, from some of the comments reported throughout this chapter, that not all students were aware of this.

The general consensus of students was that **sigma** may benefit from better advertising, with it being acknowledged by some that they knew some advertising was done, but it would be more effective if the advertising was more meaningful. This meant that the advertising should be more engaging and tailored to specific courses, with MSS staff being visible. Social media was also mentioned by students. The researcher created an Instagram account for this purpose at the start of 2022, with these comments further illustrating the need to use such media to encourage student engagement. Student testimonials especially seemed to be favoured by students, with many claiming having engaged students speak about their experience with **sigma** would heavily encourage engagement and set students at ease.

Although there was no intention of seeking out students that had completed the mathematical resilience intervention to participate in the interviews, one student did choose to. They specifically attributed their engagement with MSS to their participation in the intervention and said many of their peers had sought out the support for the same reason. They had engaged with the support multiple times. The intervention as a form of advertisement for the centre seems to be successful as it introduces students to an MSS tutor, therefore lessening the barrier of fearing the unknown and maybe even partially, the fear that they will be judged by the tutors. This sense of familiarity may be particularly beneficial to anxious students in particular as discussed in previous chapters, too.

Interviewer:

> *“Have you used **sigma** before?*

Respondent 21:

"I hadn't until you did the intervention, and then I actually did go and use it… it was a couple of us that went together and we were just having a bit of an issue with one of the lab questions and the calculations for it. So we went over to the ***sigma*** *and they went through it with us. So that, that* [sic] *did help us a lot."*

Respondent 21:

"There's usually a group of us, so I know that a couple of the girls from the kind of group that we've got in uni, they've been and used it a couple of times as well."

8.5 Discussion

The aim of the interviews was to give deeper understanding of some of the results found in the previous chapters of this research. Some themes that emerged overall aligned with specific questions, whilst some were enlightening due to the insight they provided into the attitudes that influenced student engagement with MSS. For clarity, themes have been separated according to the two main questions sought to be answered in this chapter: why do students engage, and why do students not engage, with some themes crossing both questions, such as personality.

Figure 8.1

Diagram to outline student reasons for engagement

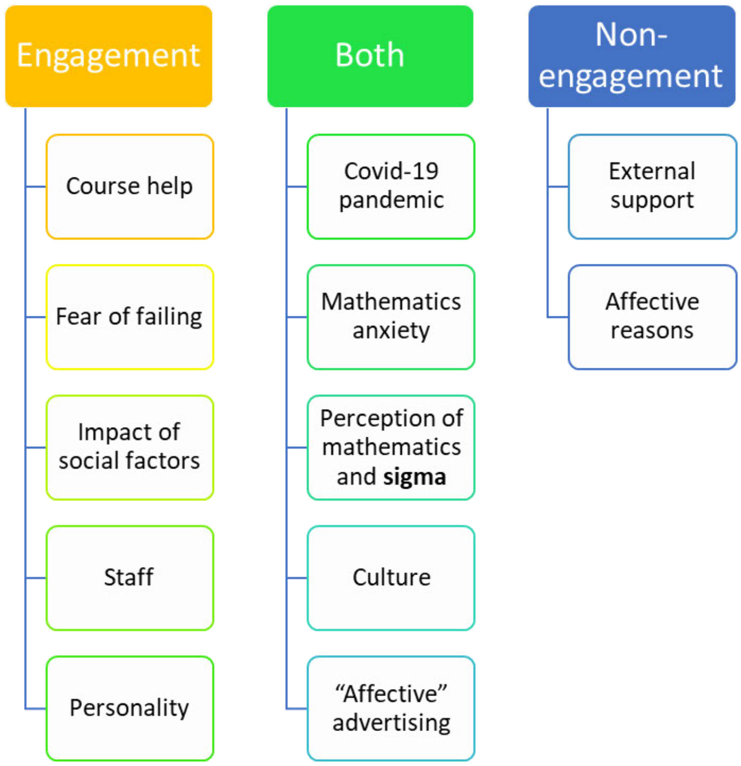


Figure 8.1 gives an overview of the reasons students gave for their (and other students') level of engagement with MSS as well as some key points that may benefit from other exploration. Students that chose to not engage had several affective reasons for not engaging, such as MA or embarrassment. There were also some who said they had strong external sources for support which they sought out rather than engaging with MSS. However, it can be inferred that those who mentioned external sources of support may rely on these people due to the familiarity they have with them, and so any situation that may involve them being seen as stupid, for example, can be avoided.

Whilst previous literature has cited structures of MSS as hindering their engagement, these were rarely mentioned by students in the interviews. For those that did, many mentioned other affective reasons after the structural reason. What was surprising was that students also cited course help as their "shallow" reason for engaging before they shared the reason for *why* they sought course help, such as wanting reassurance from a "patient" tutor or being so scared of failing that it forced their engagement. Fear encouraging engagement supports what was found in Chapter 7 and in Grehan et al. (2016).

"Hitting rock bottom" also influenced the possibility of a student engaging. Students claimed to turn to MSS or that they would turn to MSS when it was their only option to prevent them from failing their course or module. This is reminiscent of what Grehan et al. (2016) shared about the influence of critical events on engagement. This especially seemed to be the case for some anxious students, who referred to seeking support as the "lesser of two evils", which is quite an evocative statement when it is realised that seeking support with mathematics was still seen as a negative to this student, even if it was not as bad as failing their course. When students were also asked to reflect on whether MA would hinder or encourage engagement, most believed it would hinder engagement, perhaps indicating how they would react should they have suffered from MA, which some did. Others however, stated that MA could encourage engagement since students would want to seek any avenue of support.

Another notable finding was that reasons could be reasons for either student engagement or non-engagement. Students claimed having a friend to visit **sigma** with encouraged them as it meant they were not alone; the experience would be less daunting. However, as mentioned above, having a strong support system could also mean students went to friends for support rather than visiting MSS. Also, having a resilient personality was seen as being likely to promote engagement. Whilst the flip-side of this was that not having a resilient personality was seen as being likely to lead to non-engagement.

Perceptions around **sigma** meant those who saw the staff as friendly and approachable creating a safer space to seek support engaged, whereas those who were concerned that **sigma** staff would be judgemental or thought **sigma** was only for mathematicians avoided it. Students also remarked on how they felt less able to seek support in their later academic years because they had internalised the belief that they should not be asking for help with "easier" content at this stage. This may have been established through comments made by lecturers. However, others thought seeking support became easier as they were more easily able to formulate their questions. Whilst the sample of students for the interviews was skewed towards postgraduate students, this finding is particularly of note since student engagement with **sigma** is typically at its highest in year one. Further research into this may be of benefit.

The personality of students was gauged through the way they responded to questions since there was no direct measurement of personality traits in the interviews. Many facets of their personality became clear, including but not restricted to, resilience, help-seeking, motivation and neuroticism (anxiety). Again, this was an incredibly polarising factor in that the interrelatedness of the facets of students' personalities impacted their engagement with **sigma**, particularly how likely they were to seek help. For example, an anxious student would either seek out support or not depending on their levels of anxiety, their type of anxiety, and most important of all, their willingness to seek help and how they viewed seeking help.

External support was the most cited factor for why students did not engage with **sigma**. There is a preference for seeking help from peers or people they already know (this confirms findings reported in Table 7.13) rather than seeking support from unknown MSS staff. MSS providers would not claim that they are the only useful source of help for learners and would not want to deter students from seeking help from their peers. However, there is a question as to whether this external support is enough. That students feel more comfortable approaching their peers is perfectly understandable, and often peers will be able to help with a specific question. However, the overall quality of assistance that peers can give is unlikely to be of the same level as that given by MSS tutors. It is likely that much peer-support consists of "giving the answer" rather than focusing on developing understanding. Again, there may be lessons to be learned here in how MSS providers describe their services to students. It may be advantageous to put more emphasis on the benefits of students developing a more holistic understanding of mathematics or statistics.

Culture and students' perception of mathematics also significantly influenced their likelihood of seeking support, and maybe even their levels of MR. One of the dimensions of MR is struggle, and this is one of the aspects of mathematics students seemed most unable to comprehend.

Particularly in Chapter 7, MSS is seen as a space only for weak students with weakness being identified by the fact that they struggle with learning mathematics. Consequently, some students were hesitant to use the support out of fear of being viewed as a weak student or looking stupid. This is supported in this chapter, where most students discuss the seemingly inherent difficulty of mathematics, further mentioning that having family and friends who spoke of the difficulty and inaccessibility of mathematics had some bearing on a student's own thoughts about the subject; if family spoke about the importance and value of mathematics, this could either reinforce the assumption that mathematics must be difficult, or it encouraged students to exert effort into learning and seeking support where necessary.

Students were also asked how **sigma** may increase student engagement, chiefly for those students that may be mathematically anxious. Whilst posters and advertising through lecturers has been broadly successful, it is clear that more needs to be done to engage those that need help, but do not (yet) avail themselves of the support. The distinction between these students and those that have engaged may be that affective reasons, such as MA and embarrassment, are hindering their engagement, as suggested in this chapter and in Chapter 7. Methods to increase student engagement must therefore take this into consideration. What can be done to help students overcome any fears around the unknown, embarrassment, looking stupid, and admitting their struggle with mathematics? Student testimonials may be one such method, as well as the MA intervention. Messages must also be delivered in a manner that is visible to those non-engaged students; whilst posters around the centre detailing the ethos of the centre may be useful for engaged students, they will not reach the target audience.

Many such suggestions were returned, and students spoke highly of the current advertising practices in place, such as students receiving a free calculator when they visited the centre for the first time upon completion of an attitude about mathematics and MSS survey. The main feedback received was that more should be done to advertise the centre, which the author interpreted as the perception of **sigma** at the University needing some change. It was evident from both the interviews and the engagement questionnaire that students knew little of what **sigma** was, what it had to offer and how it operates. This clearly establishes the need for more effective advertising, with the goal being for advertising to address affective as well as process reasons for non-engagement. It must be considered that the form of advertising needed to do the former may be different from the form of advertising needed for the latter. Such messages could be shared across the university via social media and other such mediums.

Some ways "affective" communication could be achieved are now detailed. There is a necessity for communication with students to include information targeted at MA students and less mathematically-confident students that they could seek support, whilst also showing that the support was not only for "struggling" students, as mentioned in Chapter 7. Despite online support having been mentioned by students, some did not know of its existence, again, as found in Chapter 7. One student even suggested online support as a method for encouraging engagement for anxious students, who may benefit from the anonymity that online support offers. The one method that was mentioned by most of the students as being one way forward was the use of student testimonials. Students were more liable to believe the word of their peers on the usefulness of **sigma**. One student even mentioned that without their friend repeatedly suggesting asking **sigma** for help, they would not *"have been so quick to go*". This suggests that MSS providers might need to be more nuanced in their advertising. There is often a major emphasis on the fact that MSS provides one-to-one individualised support. This is something that is very attractive to many students. Indeed, this feature was identified by student users as, overwhelmingly, the most valued aspect of MSS (Lawson et al., 2001b). However, whilst this appeals to some users, it might also be that it is something that deters other students from engaging since their personality finds such focused individual attention intimidating. Advertising which makes clear that there are different ways of engaging with MSS and that coming with a friend is just as acceptable as coming on your own may go some way to addressing this.

It was also mentioned that having MSS staff personally advertise the centre may be of benefit. This may be because it can showcase the approachability of the staff members and the non-judgemental nature of the centre, which was a recurring theme in this chapter, throughout the different questions posed. Course teams have direct access to students that MSS core staff do not have and therefore, the cultivation of relationships with course teams can be beneficial. This was especially true during the pandemic when it was especially difficult for MSS staff to contact student groups directly. Embedding some support within course activities will particularly assist those students who feel they would benefit from knowing the MSS staff before accessing the support available. This space can be used for MSS staff to share the ethos of the centre with all students, including those that have not yet engaged, particularly that the staff are not judgemental, the space is for all students and no question will be considered as too simple.

8.6 Summary

Many interesting themes arose as a result of the analysis of 23 semi-structured interviews. Namely, students who had not engaged with MSS appeared to view the centre as an intimidating place and shared concerns about being made to feel stupid by staff. Those that had engaged with MSS stated the staff to be a strong positive of the support and a reason for continued engagement. Their perception of their own ability also affected this as well as the views of those around them and the culture that they had grown up with, with notable differences between international and home students.

Clearly, changes need to be made to the way students perceive mathematics so that they may change their perception of MSS too with most students discussing their negative perception of mathematics, even if they are able to recognise its importance. This would be a huge undertaking, so as an alternative, changes could be made to the way the nature of MSS is communicated to the student population to ensure they know **sigma** is a safe space to seek support.

It also appeared that there was an interesting relationship between the types of fear students felt and that if students' fear of failure outweighed their fear of being judged, they were more liable to avail of the support. Many students displayed signs of suffering from some level of MA, even if they were unable to recognise this. In many cases, these were the students that initially gave "normal" responses for their level of engagement, before later discussing how mathematics made them feel.

The key findings are summarised below.

- A driving motivator for both engagement and non-engagement is fear. If fear of failure outweighs other fears, such as embarrassment, students may be more likely to engage.
- Perception of **sigma** varies greatly between those that have engaged and those that have not.
- Advertising practices that highlight the approachability and non-judgemental nature of MSS staff may be of particular benefit to anxious students especially because it may reduce their fears around being judged, which is inhibiting engagement.
- Students do not want to share affective reasons at first and may share reasons such as seeking course help or not having need of the support. When they are speaking of others' engagement and of their own past with mathematics, they are more likely to share their beliefs about mathematics and what drives their engagement. This can help direct how future data is collected from students.
- The intervention encouraged a group of students to engage with the centre that had previously not engaged. The intervention may benefit students through not only

informing them in detail about **sigma**, but also by making students familiar with MSS staff.

- Advertising should not only be focused at the start of the academic year. Repeating advertising practices before the examination period may encourage student engagement by reminding them of the support available.
- Student recommendations, social media and personal lecture shout-outs are key avenues to explore in terms of effective advertising strategies.

9 Conclusions and recommendations for future practice

9.1 Introduction

This research has sought to investigate student engagement and non-engagement with MSS, particularly the effect that student demographic characteristics, MA, and MR have on whether a student chooses to use support and how often they engage. While this area is relatively unexplored in relation to MSS, the research it is situated among is presented in Chapter 2. Chapter 3 details the research methodologies used within this study, whilst the findings are shared in Chapters 4, 5, 6, 7, and 8, answering the research questions presented in Section 1.2. Before providing conclusions and recommendations based on the work of this thesis, the environment in which this research study took place is discussed as well as the limitations of the study.

9.2 Setting of the research study

This thesis is situated among both the pre- and post-COVID pandemic years which definitely impacted students' study behaviours. In particular, the uncertainty around the pandemic and the disturbances to the regular teaching of mathematics at A-level and degree level may have had some bearing on student levels of MA. Use of the Betz MA scale (1978) gives a measure of the MA levels of current students, but we do not have pre-covid levels of MA to make a comparison with the current values. However, it seems likely that the pandemic may have led to higher levels of MA amongst students, since it has been reported that student general anxiety levels have increased as a result of the pandemic (Kan et al., 2021). This only further highlights the importance of measuring MA in students and helping them in mediating it.

Furthermore, during the pandemic there was substantial reluctance on the part of students to be involved in initiatives beyond their direct course of study. This hindered recruitment of participants for many of the qualitative data gathering activities of this study. Indeed, most data gathered for this study was collected once the worst of the pandemic was over and students were back on campus. Some participants had only experienced online teaching during their degree at the point of participation whilst others had their regular teaching interrupted, which is reflected in some interviewee responses. The lack of responses during the pandemic does increase the difficulty of comparing student experiences accurately, but since the interview responses were predominately collected during "hybrid" learning, these may be of most benefit going forward in the post-pandemic hybrid teaching landscape.

Finally, the interruption to teaching caused by COVID meant that it was impossible to study consecutive "regular" academic years. Student behaviour was vastly changed during the pandemic and so there was no opportunity to monitor student habits across their undergraduate journey, which may have provided more insight into why student behaviour changed across the different academic years. Therefore, further work analysing student usage data and demographic data may be of benefit.

9.3 Limitations

Throughout this thesis, some students have been treated as a homogeneous group. This was necessary for a rigorous analysis. For example, to have a viable sample size, all disabilities were grouped into a single category. In reality, there are many different disabilities, with each benefitting from different types of support. Future work should consider these specific differences, which would further research in this field. However, there were other focuses of this research.

As the sample for the online intervention and interviews was self-selecting, the participants may not be representative of the whole student population in that the students that took part were perhaps more likely to have elevated levels of motivation and resilience than those who did not volunteer to participate. These personality traits have been highlighted to influence whether a student engages with mathematics support. Therefore, there is a potential bias in the interview data in particular. The results may not accurately reflect the opinion of the average student at CU. However, to mitigate this, several students in this sample have yet to engage with sigma or have now chosen to receive support from external systems, despite having once engaged with MSS. It is reasonable to believe that the opinions of these students do represent at least part of the picture of the reasons for non-engagement with MSS. The sample for the interviews was also heavily skewed towards PhD students, who, as shown throughout the results chapters, are not the typical MSS users. However, their experience with higher education and their greater maturity provides them with insight on engagement that non-mature students may not feel comfortable with providing.

Furthermore, the researcher did not have prior experience with interviewing or delivering interventions. This may have influenced the fluency of their delivery. Evidence that students did not feel the need to display themselves in a certain way to the researcher can be seen through the way some students have been very open, even with sharing negative opinions about MSS and explaining their true views of mathematics. The researcher also facilitated a non-judgmental atmosphere during the sessions to ensure that students knew there was no pressure upon them to respond in certain ways. This was accomplished by repeatedly reassuring students throughout the sessions and speaking to them briefly beforehand to reassure them of the anonymity of their responses.

The researcher delivered the interviews and the intervention, and thus, the researcher may over-interpret results or overlook limitations (Wilshire, 2017), creating bias. This danger was mitigated through the use of piloting, allowing the researcher time to reflect on the process. Furthermore, using a second coder, completely independent of the research process, provided a barrier to over-interpretation.

Considering that the MAMR questionnaire was delivered during the academic years of 2020/21 and 2021/22, this may have influenced student MA and MR scores due to the uncertainty around studying and the pandemic. When students completed the questionnaire in relation to their first time engaging with the centre was not recorded. Therefore, it must be considered that the levels of MA and MR recorded by the questionnaires may not wholly reflect students' MA and MR levels at the time of their engagement with **sigma**.

Although the dataset is reasonably extensive (over 100 students) for the engagement questionnaire, it is heavily dominated by responses made during 2021/22, with only eight responses given in 2020/21. The prevailing COVID situation was very different during these two years. In 2020/21, almost all Higher Education provision was online (for a short period of time, a very limited face-to-face MSS service was offered), whilst, in 2021/22, most Higher Education provision (including MSS) was primarily in-person, with some online services. Although it was hoped for an even spread of responses across the two years, in terms of learning for the future, responses from 2021/22 are probably more valuable since the circumstances prevailing in that year are more similar to those going forward.

Considering the main limitations of the research for this thesis, the implications of each chapter's results and how they provide answers to the four main research questions of the study will now be discussed holistically whilst also informing recommendations for future practice and work in this field.

9.4 Summary of findings

In this section, results from all chapters are drawn together so that the original research questions may be answered. Results are separated by the research question they answer. Since the research followed a mixed-methods approach and a triangulation design guided the research, some results answered multiple research questions. In this case, it is situated with the research question it most closely aligns with.

9.4.1 RQ1: How do student characteristics affect student engagement with MSS?

- There was a considerable drop in engagement during the pandemic. The pandemic also altered which students engaged, with a switch away from engineering and mathematics students towards those on health-related courses.

- Those students who did engage tended to make, on average, a similar number of visits as before the pandemic. This indicates that students judged the quality of online support to be comparable to that of face-to-face. Therefore, the challenge lies in encouraging students to initially visit; once they had used the online support, the quality of the support was sufficient.

- Engagement with MSS can be modelled well using a two-stage hurdle model. One part of the model, based on logistic regression, is used to predict the effect of various demographic factors on whether students engage with MSS or not. The other part of the model, using a negative binomial distribution, predicts the effect of these factors on the number of visits made by students who do engage.

- An overview of the significance of factors prior to and during the pandemic can be seen in Table 9.1.

Table 9.1

Significant predictors of whether or not students engage and the number of repeat visits they make, indicating the groups most like to engage or make the most visits

	2018/19		2020/21	
	Engaged or not	**Repeat visits**	**Engaged or not**	**Repeat visits**
Gender	Female	Female	Female	Not significant
Ethnicity	Diverse	Not significant	Not significant	Not significant
Age	Mature	Mature	Mature	Not significant
Course type	A level required	A level required	No A level	Not significant
Disability	Disabled	Not significant	Disabled	Not significant
Nationality	International	Home	International	Home

- In 2018/19, in most cases, the students in the group that were predicted to engage had higher levels of MA than their counterparts, except for course type (where those on A level Mathematics required have much lower levels of MA), nationality, and ethnicity where the difference is negligible. They are also those that are typically demographically underrepresented.

- In 2020/21, the results for engagement or not were similar, but there were some critical differences. Ethnicity was no longer a significant predictor of engagement.

Furthermore, although course type remained a significant predictor, the course type A level required predicted lower engagement than no mathematics required – a reversal of the situation in 2018/19. Furthermore, there was a more pronounced difference in engagement for those factors that remained significant.

- In terms of the number of visits made in 2020/21, only nationality was a significant predictor. This perhaps indicates that the disruption caused by the pandemic outweighed the effects of the demographic factors.

- One factor that caused an increase in the engagement of Bioscience students was the intervention. Their engagement increased from 7.28% to 12.57% during the pandemic, when typically, engagement for mathematically dense courses had dropped. This may be due to the anonymity online support provides and because of the successful liaising with the Bioscience lecturers.

9.4.2 RQ2: What effect, if any, do MA and MR have on student engagement with MSS?

- The hurdle model described above can be extended to include the effects of MA and MR as independent predictor variables. The accuracy of this model is good but not as good as that for the case above, although this may be primarily due to a much smaller sample size.

- MA was a significant predictor of engagement, with a higher MA score predicting more engagement with **sigma**, providing evidence that students with high MA do use the centre, despite the assumption that they may be too anxious to do so. Generally, MR levels were high in the sample size, which may have mitigated high MA levels.

- It should be noted, as shown in Figure 5.1, that engagement does start to reduce at very high levels of MA for those with medium levels of MR. The statistical models used here do not have the granularity to show this detailed effect.

- Ethnicity predicts student engagement when other factors, including MA, are controlled for, with ethnically diverse students engaging significantly more.

- Course type also significantly predicts engagement when MA and MR are included in the model.

- Disability is a borderline significant factor in predicting repeat engagement when other factors, including MA and MR, are controlled for. More investigation would be of interest.

- There appears to be a complex relationship between MA, demographic factors and engagement, with particular demographic groups, such as female students, disabled students, and mature students, having significantly higher engagement with **sigma** (in 2020/21) and higher MA scores, too. When MA was added to the hurdle model, gender, disability, and age were no longer significant predictors, whilst course type, ethnicity and MA were, indicating that for the first three factors, there is perhaps a strong interaction with MA.

9.4.3 RQ3: What is the effect, if any, of developing students' levels of MR on their engagement with MSS?

- Interestingly, when MA as a predictor of engagement was investigated in a subset of students that had participated in the intervention, it was found that an increase in a student's MA during their academic journey predicted an increase in the number of visits for students who visited the centre in the same academic year that typically saw engagement from that course.

- For students in the academic year that their course-mates did not typically engage in, an increase in a student's MA during their academic journey predicted a decrease in their visits to MSS. The difference in an individual student's MA score across their academic journey (or part of it) may predict engagement rather than a high MA score, as indicated in Section 9.3.2.

- Online interventions for reducing MA may benefit more anxious students.

- The change in MA and MR for students from before the intervention was not significant.

- The intervention was most effective (in terms of reducing MA) for students with high pre-intervention MA.

- 86% of students said they were more likely to use MSS due to the intervention.

- Around 55% of participants engaged with the centre after the intervention.

- MR score does not significantly predict engagement, nor does a student's change in MR score.

- The intervention may be beneficial as an advertising tool for **sigma**, particularly for anxious students, to ensure they know support is available should they need it. Barriers such as not knowing how to access support and what happens in a support interaction are reduced by the intervention.

- The intervention was adequately adapted for use in an online and face-to-face environment and could be delivered in under an hour, if necessary, during lecture time. Just informing students about MA, its effect on learning, and strategies that could be used to mitigate these effects (which can be condensed into ten minutes) seemed to be the most critical aspects of the intervention.

- Staff levels of MA and MR influenced students' attitudes toward mathematics, especially when they were open about their struggles with the subject with their students (Lau et al., 2022). Some staff also confided in the researcher that they felt unable to seek support or discuss their difficulties with mathematics.

- Qualitative feedback for the intervention was broadly positive, with many responses highlighting its benefits.

9.4.4 RQ4: How do students explain their level of engagement with MSS?

- Many students have a skewed perception of **sigma**. Students see it as remedial, hindering their engagement as they do not want to appear weak to their peers. There is a clear distinction in how engaged and non-engaged students view **sigma**. Students are concerned about their lack of knowledge and assume that MSS staff do not struggle with mathematics.

- Affective reasons are given for engagement and non-engagement, indicating that this needs to be considered more when encouraging students to avail of the support.

- Affective reasons that hindered engagement were cited by 37% of non-users when asked how affective reasons influenced their non-engagement.

- A particularly concerning finding is that the same number of students would prefer to "do nothing" about their mathematical concerns as a first choice as they would engage with **sigma**. One student likened seeking MSS to the "*lesser of two evils*" when the other option was failing, emphasising the need to support students with whatever affective reason is hindering their engagement (such as MA).

- Seeking support through the internet or from lecturers/peers is their preferred option of support. This may be because they are familiar with the people they are asking and, thus, may feel more comfortable admitting any difficulties with their mathematics content.

- The primary reason students seek support is for course help, but for most, fear of failure prompts this engagement. One student shared that "*hitting rock bottom*" showed them they "*did need to seek that support.*" A similar thing is seen for non-engaged students; whilst students initially give reasons such as choosing to use external support rather than **sigma**, it is often because they feel they may be judged by MSS staff for not knowing much mathematics.

- A powerful motivator for both engagement and non-engagement is fear. Students may be more likely to engage if their fear of failure outweighs other fears, such as embarrassment.

- Culture, year of study, student perception of mathematics in general and perception of their mathematical ability affects how a student views both mathematics and seeking support.

9.5 Implications and recommendations for future practice

Since engagement with MSS is voluntary, understanding what may drive engagement or dissuade it is vital to the continued success of **sigma** and other MSSCs, the academic success of HE students, and universities as a whole. Findings may also benefit other university-based academic support who wish to investigate engagement with their services.

9.5.1 Key recommendations

9.5.1.1 "Affective" Communication

- It is evident that current advertising practices are not effectively communicating the nature of MSS to students, which may deter students from engaging. Advertising practices that highlight the approachability and non-judgemental nature of MSS staff may be of particular benefit to anxious students, especially because it may reduce their fears of being judged, which is inhibiting engagement.

- Employing student proctors and having lecturers from traditionally non-engaged courses (such as Biosciences and Computer Science) deliver their office hours in **sigma** will aid in increasing MSS visibility on these courses and, thus, engagement. The intervention provided evidence that increasing the visibility of MSS and highlighting its non-judgemental nature does aid in achieving this aim.

- There may be value in embedding support activities into class timetables to demystify MSS and correct skewed perceptions about the service and the staff.

- The intervention encouraged a group of students to engage with the centre that had previously not engaged. The intervention may benefit students by informing them in detail about **sigma** and by making students familiar with MSS staff.

- Advertising should not only be focused at the start of the academic year. Repeating advertising practices before the examination period may encourage student engagement by reminding them of the available support.

- Student recommendations, social media and personal lecture shout-outs are vital avenues to explore in terms of effective communication strategies.

- Current communication practices could be more effective by detailing how MSS is for all students and how the support can be accessed.

9.5.1.2 Online support

- Online interventions may be more beneficial for anxious students. The MA intervention, or the PowerPoint slides, should be shared with students who display such behaviours.

- Online MSS should continue to be offered at all institutions where funding allows, even if it is only offered on a limited basis. It is clear from this study that this space offers some students who may not typically engage with MSS the option of doing so, with many traditionally non-engaged (and potentially at-risk) students availing of such support.

- Resources on MA should be made available on MSS websites – links to external resources, such as those used in the intervention, should be included, with the page on MA made central and easy to navigate.

9.5.1.3 Future data collection

- Students are liable to give “shallow” reasons for both engagement and non-engagement, such as “course help”, before they share the underlying motivations, for example, “fear of failure”. Open-ended questions used in this study have resulted in very few, if any, students giving these shallow reasons in questionnaire format, too. This should be used to direct how future data is collected from students.

9.5.1.4 Implications of predictors of engagement

- MA significantly predicts student visits, which should direct how students are supported. Resources and advertising practices should adapt accordingly to support these students, and such advertising strategies should be developed to be shared across multiple platforms, including the website and social media. The resources used to encourage the engagement of MA students may be different to those currently in use. Students that seek support should be directed to these resources so that they are not only aware of MA and its prevalence but also how its effects can be mitigated (including through the use of MSS).

- MA appears to be significantly related to the engagement of disabled, mature and female students. Support for such groups should be appropriately tailored, and it should be of utmost importance to support such students with any struggles they have with their MA.

- The purpose of MSS is to support students with their course content – whilst an increase in students' MA may prompt their engagement, it does not encourage repeat engagement. All MSS centres should aim to continue supporting such students by reducing the adverse effects of their MA. The goal is to reduce their MA and increase their MR - reducing their MA means they will stay in the growth zone for longer, and increasing their MR will mean they understand the need to struggle and get help.

9.6 Future work

From the qualitative and quantitative analyses conducted within this study, much has been found around the effect of MA, MR, student characteristics, and the impact of the MR intervention on engagement with MSS. Student reasons for engagement have also been shared, some of which support previous literature, whilst other findings are entirely novel in the field. However, further work may be of benefit to understand how these findings apply to the support systems in different universities, as well as how this work can be taken further to encourage student engagement across various courses, demographic groups, and mathematical abilities. These findings may also be relevant to practitioners interested in understanding how and why engagement with mathematics itself differs from engagement with MSS and how to increase student engagement with the mathematical content in their courses. Practitioners of other university-based academic support services may also find the results from this study beneficial.

It is concerning that students view **sigma** as remedial support, particularly since, for many students, it hinders their engagement. Future work could research why this is the case and how it may be remedied.

Considering that lecturing staff have been found to impact engagement positively (Hodds, 2020a) and that student recommendation is the key form of advertising suggested by students, it may be of merit to investigate further how the relationship of students with their peers and lecturers impacts their engagement. Many either cite their friends or lecturers as a reason for their level of engagement (or non-engagement) with MSS. Although the research presented in this thesis has begun to address some of these issues there is scope to explore this in much greater depth.

It is also noted that **sigma**, when support was in-person in 2018/19, had almost all mathematics students engage with the support. Mathematicians typically use the centre to work with their peers. Despite multiple efforts, online support, which did not provide this collaborative environment, returned a different level of engagement from these students Now that the physical drop-in centres are open again, the possibility for them to be social learning spaces has returned. Ways of promoting this to wider groups of students than just mathematicians should be further investigated. This will probably involve liaison with course teams. The wider role of course teams and teaching staff in promoting engagement with MSS is another area which may benefit from more rigorous evaluation.

There is a need to reinforce messages about MA being manageable and about the benefit of MSS as well, which can also be done effectively by module lecturers. However, for this to be possible, lecturers must be willing to use some of their student contact hours on sharing these key messages, although each reinforcement can be quite short. For MSS staff, identifying MA students and taking a few minutes to cover the intervention content (primarily, the manageable nature of MA) can greatly support students and also reinforce the ethos of the centre. Therefore, it is clear that a one-off intervention, whilst being of some benefit for students, does not, on its own, solve the problem of debilitating MA in students.

Connecting whether it is students with A level qualifications in mathematics, BTEC qualifications or otherwise, who do not engage with the centre but may benefit from support could determine which groups of students could be targeted for specialised **sigma** workshops. Due to data collection delays, students' prior qualifications regarding their engagement with

MSS could not be researched. Instead, students were grouped into three groups according to their course's mathematics prerequisite.

Demographic engagement differs among different groups, but the reasoning for this is unclear. Further interviews focusing on the different demographic groups may be helpful, especially since findings from interviews have also highlighted the effect of culture, community and year of study on their engagement. Had there been prior knowledge of the nature of students in the sample, it may have been that different questions would have been asked during the interviews, specifically around the impact of age and maturity on engagement. Future work targeting undergraduates for such interviews may also give additional insights.

The relationship between MA and engagement, particularly amongst female students, disabled students, and mature students, is of considerable interest. It may be worth investigating whether the high levels of MA amongst these demographic groups drive their engagement, and if so, why it encourages it rather than act as a barrier. It would also be helpful for more research to identify which students specifically are deterred from seeking support because of their MA and who is encouraged.

The work in this thesis strongly confirms the benefit of measuring MA in students when investigating student engagement behaviour with MSS. However, it is also evident that there is not such a strong link between MR and engagement. This may be because of the high levels of MR demonstrated in the student sample, which may be because pursuing higher education requires a certain degree of MR. For future work, it is suggested that more focus should be placed on MA; however, increasing levels of MR in students may still be one way of reducing the effects of MA.

Finally, the results from this study found that the suggestion made by Symonds et al. (2008) about structural reasons for non-engagement being a mask for affective reasons and findings from Grehan et al. (2010) about fear inhibiting engagement with MSS were confirmed herein and built upon. The work completed around MA within this study shows that high levels of MA predict engagement, but from the interviews and intervention, it is clear that this only holds for some students. The nature of the statistical models used in this study cannot predict fine detailed changes in behaviour along an ordinal scale such as MA. The model used in this research cannot predict the behaviour of students with high levels of MA and differing levels of MR. However, the raw data suggests that engagement increases monotonically for students with medium levels of MR but follows a modified inverted U curve (Wang et al., 2015) for students with high MR. Future work using a different model that investigates the relationship between MA and student visits at different levels of MR may provide further critical insight into this relationship.

A particular concern that emerged from the engagement questionnaires was that some students indicated that when they needed support they would rather "do nothing" than engage with MSS. It would be very valuable to explore the reasons behind these responses in greater detail.

To summarise, this research has made a valuable and unique contribution to the area of student engagement with MSS by delving into the impact that demographic factors, MA, MR, and an MA intervention have on engagement. It has also identified why some at-risk students may not engage with the support. Furthermore, this thesis has shed light on potential avenues for further research to build off of the findings discussed.

References

Abu-Hilal, M.M. and Al Abed, A.S. (2019). Relations among engagement, self-efficacy, and anxiety in mathematics among Omani students. *Electronic Journal of Research in Educational Psychology*, 17(2), 241-266. https://doi.org/10.25115/ejrep.v17i48.2182.

ACME (2011). *Mathematics in the workplace and in higher education*. London: The Royal Society.

Adams, A., & Cox, A. L. (2008). *Questionnaires, in-depth interviews and focus groups* (pp. 17-34). Cambridge University Press.

Adedoyin, O.B. and Soykan, E. (2020). Covid-19 pandemic and online learning: the challenges and opportunities. Interactive learning environments, pp.1-13.

Ahlfeldt, S., Mehta, S., and Sellnow, T. (2005). Measurement and analysis of student engagement in university classes where varying levels of pbl methods of instruction are in use. *Higher Education Research and Development*, 24(1):5–20.

Ahmed, S., Davidson, P., Durkacz, K., Macdonald, C., Richard, M., and Walker, A. (2018). The provision of mathematics and statistics support in Scottish higher education institutions (2017): a comparative study by the Scottish mathematics support network. *MSOR Connections*, *16*(3), 5–19.

Akin, A. and Kurbanoglu, I.N. (2011). The relationships between math anxiety, math attitudes, and self-efficacy: A structural equation model. *Studia Psychologica*, *53*(3), p.263.

Alpers, B. (2008) "What are the major problems facing Engineering Maths Education in Europe?", *Proceedings of the 14th SEFI (MWG)/IMA Conference,* Loughborough, April 2008.

Alrashidi, O., Phan, H. P., and Ngu, B. H. (2016). Academic engagement: An overview of its definitions, dimensions, and major conceptualisations. *International Education Studies*, 9(12):41–52.

AAPOR (American Association for Public Opinion Research). (2021). Question Wording. [Online] Available at: https://aapor.org/wp-content/uploads/2023/01/Question-Wording.pdf

Appleton, J. J., Christenson, S. L., and Furlong, M. J. (2008). Student engagement with school: Critical conceptual and methodological issues of the construct. *Psychology in the Schools*, 45(5):369–386.

Appleton, J. J., Christenson, S. L., Kim, D., and Reschly, A. L. (2006). Measuring cognitive and psychological engagement: Validation of the student engagement instrument. *Journal of school psychology*, 44(5):427–445.

Audas, R., & Willms, J. D. (2001*). Engagement and dropping out of school: A life course perspective.* Human Resources Development Canada. Retrieved on June 1st, 2023, from: https://publications.gc.ca/collections/Collection/MP32-28-01-1-10E.pdf.

Bailey, K. (1994). Interview Studies in Methods of Social Research. 4th ed. New York: Simon and Schuster.

Baker, J. (2021). *'You See it Differently Once You Calm Down': Developing an Intervention to Support Learners to Address Their Mathematics Anxiety* (Doctoral dissertation, University of Warwick).

Baloglu, M. (2004). Statistics anxiety and MA: Some interesting differences. Educational Research Quarterly, 27(3), 38-48.

Baloglu, M. and Kocak, R. (2006) A multivariate investigation of the differences in MA. Personality and individual differences, 40(7), pp.1325-1335.

Banki, S. R. (2021). “Learning alone-a with corona”: Two challenges and four principles of tertiary teaching. Journal of Research in Innovative Teaching and Learning, 14(1), 65- 74. https://doi.org/10.1108/JRIT-12-2020-0081

Batchelor, J. (2016). *A mixed methods study of the effects of clicker use on math anxiety and achievement in mathematics,* Iowa: Iowa State University.

BBSRC. (2010). *The age of bioscience: Strategic plan 2010–2015*. Swindon: Biotechnology and Biological Sciences Research Council. Retrieved from https://webarchive.nationalarchives.gov.uk/20101115130352/http://www.bbsrc.ac.uk/publications/planning/strategy/strategic-planindex.aspx

Beilock, S.L., Gunderson, E.A., Ramirez, G. and Levine, S.C. (2010). Female teachers’ math anxiety affects girls’ math achievement. *Proceedings of the National Academy of Sciences*, *107*(5), pp.1860-1863.

Bendig, A.W. & Hughes, J.B. (1954) Student attitude and achievement in a course in introductory statistics,Journal of Educational Psychology,45, pp. 268–276.

Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of counseling psychology*, 25(5):441.

Bhosale, U. (2022). *How to Deal With Imposter Syndrome in Academia.* [Online] Available at: https://www.enago.com/academy/overcome-imposter-syndrome/ [Accessed 12 June 2022].

Bingham, A. & Witkowsky, P. (2022). Deductive and inductive approaches to qualitative data analysis. In: P. M. C. Vanover & J. Saldaña, eds. Analyzing and interpreting qualitative data: After the interview. s.l.:SAGE Publications, pp. 133-146.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), pp.77-101.

Breen, C., Prendergast, M. & Carr, M. (2015). Investigating the engagement of mature students with mathematics learning support. *Teaching Mathematics and its Applications: An International Journal of the IMA*, *34*(1), pp.16-25.

British Academy. (2012). Society counts: Quantitative skills in the social sciences and humanities. London: British Academy. *Retrieved from (https://www.thebritishacademy.ac.uk/documents/206/Society-Counts-Quantitative-Skills-in-the-Social-Sciences-Humanities-Position- 3xJi9mM.pdf)*

Broecke, S., & Nicholls, T. (2007). Ethnicity and degree attainment (DfES Research Report RW92).

Bryson, C. & Hand, L. (2008). An introduction to student engagement. *SEDA special*, 22:5–13.

Canary, A. (2019). *Interview transcripts in qualitative research.* [Online]
Available at: https://www.rev.com/blog/analyze-interview-transcripts-in-qualitative-research [Accessed 29 March 2022].

Carey, E., Devine, A., Hill, F., Dowker, A., McLellan, R., & Szucs, D. (2019). *Understanding MA: Investigating the experiences of UK primary and secondary school students*. University of Cambridge, UK: Centre for Neuroscience in Education. https://doi.org/10.17863/CAM.37744.

Carifio L & Perla R. (2008). *Resolving the 50-year debate around using and misusing Likert scales.* Med Educ. 2008;42(12):1150–1152.
https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1365-2923.2008.03172.x

Carroll, C. & Gill, O. (2012). An innovative approach to evaluating the University of Limerick's Mathematics Learning Centre. *Teaching Mathematics and its Applications: An International Journal of the IMA*, 31(4):199–214.

Castelli, F.R. & Sarvary, M.A. (2021). Why students do not turn on their video cameras during online classes and an equitable and inclusive plan to encourage them to do so. *Ecology and Evolution*, *11*(8), pp.3565-3576.

Chase, P. A., Hilliard, L. J., Geldhof, G. J., Warren, D. J., & Lerner, R. M. (2014). Academic achievement in the high school years: The changing role of school engagement. *Journal of youth and adolescence*, 43(6):884–896.

Chen, L.T., & Liu, L. (2020). Methods to Analyze Likert-Type Data in Educational Technology Research. *Journal of Educational Technology Development and Exchange*, 13(2), 39-60.

Chisholm, C. (2017). *The Development of Mathematical Resilience in KS4 Learners* (Doctoral dissertation, University of Warwick).

Cliffe, E. and Rowlett, P., eds., (2012). *Good Practice on Inclusive Curricula in the Mathematical Sciences.* MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/InclusiveCurricula.pdf

Cliffe, E., Mac an Bhaird, C., Ní Fhloinn, E. & Trott, C. (2020). Mathematics instructors' awareness of accessibility barriers for disabled students. *Teaching Mathematics and its Applications: An International Journal of the IMA*, *39*(3), pp.184-200.

Cohen, L., Manion, L., & Morrison, K. (2002). *Research methods in education*. Routledge.

Cotton, D. R., Joyner, M., George, R., & Cotton, P. (2016). Understanding the gender and ethnicity attainment gap in UK higher education. *Innovations in education and teaching international*, 53(5):475–486

Cousins, S., Brindley, J., Baker, J. & Johnston-Wilder, S. (2019). Stories of mathematical resilience: How some adult learners overcame affective barriers. *Widening participation and lifelong learning*, *21*(1), pp.46-70.

Creswell, J. (2003). *Research design: qualitative, quantitative, and mixed methods approaches.* 2nd ed. ed. Thousand Oaks, CA: Sage.

Creswell, J. W. (2012) Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. *England: Pearson Education*.

Creswell, J. & Creswell, J. (2018). *Research design: qualitative, quantitative & mixed methods approaches.* 3rd ed. Los Angeles: SAGE.

Creswell, J., Plano Clark, V., Gutmann, M. & Hanson, W. (2003). An expanded typology for classifying mixed methods research into designs. *Handbook of mixed methods in social and behavioral research,* pp. 209-240.

Creswell, J.W. & Creswell, J.D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Croft, A.C. (2000). A guide to the establishment of a successful mathematics learning support centre. International Journal of Mathematical Education in Science and Technology, 31(3), pp.431-446.

Croft, A.C. (2009). Towards a culture of data collection and analysis in mathematics support centres. Paper presented at: Queensland University of Technology, (see http://www.mathcentre.ac.uk/resources/uploaded/croft2009queensland.pdf) [accessed 15th November 2022].

Croft, T., Grove, M. & Lawson, D. (2022): The importance of mathematics and statistics support in English universities: an analysis of institutionally written regulatory documents, Journal of Higher Education Policy and Management, https://doi.org/10.1080/1360080X.2021.2024639

Croft, A., Lawson, D., Hawkes, T., Grove, M., Bowers, D., & Petrie, M. (2015). Sigma–a network working. *Mathematics Today*, 50(1):36–40.

Croft, A. C., Harrison, M. C., & Robinson, C. L. (2009). Recruitment and retention of students–an integrated and holistic vision of mathematics support. *International Journal of Mathematical Education in Science and Technology*, 40(1):109–125.

Croft, T. & Grove, M. (2016). Mathematics and statistics support centres: Resources for training postgraduates and others who work in them. *MSOR Connections*, 14(3):3–13.

Cronin, A. G. (2016).*Mathematics support centre annual report 2015/16. Report*. Dublin: University College Dublin. Retrieved from http://www.ucd.ie/msc/t4media/MSC_Annual_Report_2015_2016.pdf

Cronin, A., Cole, J., Clancy, M., Breen, C., & O'Se, D. (2016). *An audit of mathematics support provision on the island of Ireland in 2015*. Dublin: National Forum for the Enhancement of Teaching and Learning in Higher Education. Retrieved from

http://www.sigma-network.ac.uk/wp-content/uploads/2019/02/Audit-of-MLS-provision-Ireland.pdf

Crosthwaite, C. & Kavanagh, L. (2012). Supporting transition, engagement and retention in first year engineering. In *Proceedings of the International Conference on Innovation, Practice and Research in Engineering Education. Coventry, England*.

Cuemath (2021). UK MATHS ANXIETY THE WORST IN THE WORLD, GLOBAL SURVEY REVEALS. (Online) Available at: https://www.fenews.co.uk/education/press-release-uk-maths-anxiety-the-worst-in-the-world-global-survey-reveals/ (Accessed 13 June 2022).

DeFranzo, S. E. (2018). *Snap Surveys.* [Online]
Available at: snapsurveys.com/blog/advantages-disadvantages-open-questions-course-eval/
[Accessed 05 06 2021].

Delderfield, R., & McHattie, H. (2018). The person-centred approach in maths skills development: Examining a case of good practice. Journal of Learning Development in Higher Education, 13, 1–10. https://doi.org/10.47408/jldhe.v0i13.447

Devault, G. (2020). *Advantages and Disadvantages of Quantitative Research.* [Online]
Available at: https://www.thebalancesmb.com/quantitative-research-advantages-and-disadvantages-2296728

Devine, A., Fawcett, K., Szűcs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and brain functions*, *8*, 1-9.

Dew, K. H., Galassi, J. P., & Galassi, M. D. (1984). Math anxiety: Relation with situational test anxiety, performance, physiological arousal, and math avoidance behavior. *Journal of Counseling Psychology*, 31(4):580.

Dogan, U. (2015). Student engagement, academic self-efficacy, and academic motivation as predictors of academic performance. *The Anthropologist*, 20(3):553–561.

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). MA: What have we learned in 60 years? *Frontiers in psychology*, 7:508.

Dowling, D. & Nolan, B. (2006). Measuring the effectiveness of a mathematics learning support centre - the Dublin city university experience. In *Proceedings of the CETL-MSOR Conference 2006; Loughborough University,* pp. 51-54.

Dudovskiy, J., n.d. *Business Research Methodology.* [Online]
Available at: https://research-methodology.net/research-methodology/research-design/exploratory-research/ [Accessed 06 06 2021].

Duggan, L., Cowan, P., & Cantley, I. (2018). Lecturers' perceptions of students' mathematical preparedness for higher education in one Institute of Technology: In the conference proceedings of the Ireland International Conference on Education (IICE-2018). In *Ireland International Conference on Education.*

Duncan, R. (2022) (Unpublished) Investigating the differences in usage and engagement with maths support, A report submitted in part fulfilment for the degree of Bachelor of Science in Mathematics and Statistics, Coventry University.

Durrani, N., & Tariq, V. (2009). Relationships between undergraduates' mathematics anxiety and their attitudes towards developing numeracy skills and perceptions of numerical competence. In *ICERI2009 Proceedings* (pp. 787-794). IATED.

du Sautoy, M. (2016). Reckon you were born without a brain for maths? Highly unlikely. The Guardian. (Online) Available at: https://www.theguardian.com/education/2016/mar/26/reckon-you-wereborn-without-a-brain-for-maths-highly-unlikely (Accessed 22 October 2021).

Dweck, C. S. (2000). *Self-theories: Their role in motivation, personality, and development*. Psychology press.

Dzator, M. & Dzator, J. (2020). The impact of mathematics and statistics support at the academic learning centre, central Queensland University. *Teaching Mathematics and its Applications: An International Journal of the IMA*, 39(1):13–28.

Edwards, A., & Carroll, D. (2018). Predictors of demand for mathematics support. In *Proceedings of the 42nd Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 395-402).

Ellicock, M., 2019. Numerate nation? *What the UK thinks about numbers*, London: National Numeracy, IPSOS MORI.

Faroa, B. D. (2017). Considering the role of tutoring in student engagement: Reflections from a South African university. *Journal of Student Affairs in Africa*, 5(2):1–15.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage.

Finn, J.D. & Zimmer, K.S. (2012). Student engagement: What is it? Why does it matter? In Handbook of research on student engagement (pp. 97-131). Springer, Boston, MA.

Fitzmaurice, O., & Mac an Bhaird, C. (2023). Effective tutoring in mathematics learning support: the student perspective. *International Journal of Mathematical Education in Science and Technology*, *54*(3), 416-432.

Ford, C. (2016). Getting Started with Hurdle Models. [Online] Available at: https://data.library.virginia.edu/getting-started-with-hurdle-models/ [Accessed 23 02 2023].

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of educational research*, 74(1):59–109.

Fredricks, J. A., Wang, M.-T., Linn, J. S., Hofkens, T. L., Sung, H., Parr, A., & Allerton, J. (2016). Using qualitative methods to develop a survey measure of math and science engagement. *Learning and Instruction*, 43:5–15.

Fredricks, J.A., Reschly, A.L. & Christenson, S.L. eds., (2019). *Handbook of student engagement interventions: Working with disengaged students*. Academic Press.

Gaille, B. (2018). *25-advantages-disadvantages-qualitative-research.* [Online] Available at: https://brandongaille.com/25-advantages-disadvantages-qualitative-research/

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), pp.296-316, https://doi.org/10.1093/teamat/hrab019

Gill, O., O'Donoghue, J., Faulkner, F., & Hannigan, A. (2010). Trends in performance of science and technology students (1997–2008) in Ireland. *International Journal of Mathematical Education in Science and Technology*, 41(3):323–339.

Gokhool, F, Lawson, D & Hodds, M. (2022), 'Investigating the relationship between mathematics anxiety, mathematical resilience and mathematics support engagement: an analysis of demographic and cohort factors', *MSOR Connections*, vol. 20, no. 2, pp. 82-93. https://doi.org/10.21100/msor.v20i2.1321

Gokhool, F., Lawson, D., Hodds, M., and Aslam, F. (2021) Exploring differential engagement with mathematics support from an engineering student focus. *Teaching Mathematics and Its Applications*. Available from: https://doi.org/10.1093/teamat/hrab033

Grehan, M., Mac an Bhaird, C., & O'Shea, A. (2016). Investigating students' levels of engagement with mathematics: critical events, motivations, and influences on behaviour. *International Journal of Mathematical Education in Science and Technology*, *47*(1), 1-28.

Grehan, M., Mac an Bhaird, C., & O'Shea, A. (2010). Why do students not avail of mathematics support? a case study of first year students at the national university of Ireland maynooth. In *Proceedings of the British Congress for Mathematics Education*, volume 30, pages 254–258. BSRLM.

Grehan, M., Mac an Bhaird, C. & O'Shea, A. (2011). Why do students not avail themselves of mathematics support? *Research in Mathematics Education*, *13*(1), pp.79-80.

Grove, M. & Croft, T. (2019). Learning to be a postgraduate tutor in a mathematics support centre. International Journal of Research in Undergraduate Mathematics Education, 5(2), pp.228-266.

Grove, M., Brown, G., Croft, T., Hibberd, S., Kyle, J., Levesley, J., & Linton, C. (2018a). Where next for mathematics education in higher education? A one-day meeting in honour of professor john Blake. *MSOR Connections*, 16(2).

Grove, M. J., Croft, T., Lawson, D., & Petrie, M. (2018b). Community perspectives of mathematics and statistics support in higher education: building the infrastructure. *Teaching Mathematics and its Applications: An International Journal of the IMA*, 37(4):171–191.

Grove, M., Croft, T., Lawson D., & Petrie M. (2018c) Community perspectives of mathematics and statistics support in higher education: the role of the staff member, *Teaching Mathematics and its Applications: An International Journal of the IMA*, Volume 38, Issue 1, March 2019, Pages 43–59, https://doi.org/10.1093/teamat/hrx017

Grove, M., Croft, T., & Lawson, D. (2020). The extent and uptake of mathematics support in higher education: results from the 2018 survey. *Teaching Mathematics and its Applications: An International Journal of the IMA*, 39(2):86–104.

Grove, M., Guiry, S., & Croft, T. (2020b). Specialist and more-able mathematics students: understanding their engagement with mathematics support. *International Journal of Mathematical Education in Science and Technology*, *51*(5), 643-668.

Hafiz, M. & Dahlan, J.A. (2017), September. Comparison of mathematical resilience among students with problem based learning and guided discovery learning model. In *Journal of Physics: Conference Series* (Vol. 895, No. 1, p. 012098). IOP Publishing.

Hanson, W. E. et al. (2005). Mixed methods research designs in counseling psychology. *Journal of counseling psychology,* 52(2), p. 224.

Hawkes, T. & Savage, M. (2000). Measuring the mathematics problem. *London: Engineering Council*.

Harper S., Carini R. & Bridges B. (2004). Gender differences in student engagement among African American undergraduates at historically Black colleges and universities, *Journal of College Student Development*, 45(3): 271–84.

Hazra, U. & Priyo, A.K.K. (2022). Unethical practices in online classes during COVID-19 pandemic: an analysis of affordances using routine activity theory. Journal of Information, Communication and Ethics in Society, (ahead-of-print).

Hiles, D.R. (2012), April. Mixed methods and the problem of the logic of inquiry. In *QMiP symposium on mixed methodology in Psychology. Annual Conference of the British Psychological Society, April*.

Hodds, M., Shao, J. & Lawson, D. (2022). Changes in student entry competencies 2001–2017. International Journal of Mathematical Education in Science and Technology, 53(7), pp.1859-1874.

Hodds, M. (2020a). A report into the changes in Mathematics and Statistics support practices due to Covid-19. http://www.sigma-network.ac.uk/wp-content/uploads/2020/07/Report-into-the-changes-in-Maths-and-Stats-Support-practice-during-Covid-19.pdf

Hodds, M. (2020b). Using Big Blue Button to support students at Coventry University. Sigma Newsletter Issue 20: Special Edition Remote Teaching, p.8-9, https://www.sigma-network.ac.uk/sigma-newsletters/

Hodds, M., (2020c). Supporting nursing students' mathematical understanding. EEC, 2015(16), pp.2016-17.

Hodds, M., Shao, J., & Lawson, D. (2022). Changes in student entry competencies 2001–2017. *International Journal of Mathematical Education in Science and Technology*, *53*(7), 1859-1874

Hodds, M. (2023). The impact of COVID-19 on mathematical entry competencies: 1 year on. *Teaching Mathematics and its Applications: An International Journal of the IMA*.

Hodgen, J., Pepper, D., Sturman, L., & Ruddock, G. (2010). Is the UK an outlier? *London: Nuffield Foundation*.

Hopko, D. R., Mahadevan, R., Bare, R. L., & Hunt, M. K. (2003). The Abbreviated Math Anxiety Scale (AMAS): Construction, Validity, and Reliability. Assessment, 10(2), 178–182. https://doi.org/10.1177/1073191103010002008

Howard, F. & Ní Fhloinn, E. (2022). What we can learn from attendance data at a mathematics support centre during and after campus closures due to COVID-19. In E. Costello, P. Girme, D. Hyland, T. Kaur, O. Kelly, T. McLoughlin, & P. Van Kampen (Eds) *Proceedings of the CASTeL 9th STEM Education Research Conference (58-65) Dublin City University.* https://doi.org/10.5281/zenodo.6902216

Hu, S. & Kuh, G. D. (2002). Being (dis) engaged in educationally purposeful activities: The influences of student and institutional characteristics. *Research in Higher Education*, 43(5):555–575.

Hunsley, J. (1987). Cognitive processes in mathematics anxiety and test anxiety: The role of appraisals, internal dialogue, and attributions. *Journal of Educational psychology*, *79*(4), pp.388–392.

Hunt, T. E., Clark-Carter, D., & Sheffield, D. (2011). The Development and Part Validation of a U.K. Scale for Mathematics Anxiety. *Journal of Psychoeducational Assessment*, 29(5), 455–466. https://doi.org/10.1177/0734282910392892

Hutauruk, A.J.B. & Priatna, N. (2017), September. Mathematical resilience of mathematics education students. In *Journal of Physics: Conference Series* (Vol. 895, No. 1, p. 012067). IOP Publishing.

Hyland, D. & O'Shea, A. (2022). The nature and prevalence of diagnostic testing in mathematics at tertiary-level in Ireland. *Teaching Mathematics and its Applications: An International Journal of the IMA*, *41*(1), pp.32-50.

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice. *Field Methods*, *18*(1), 3–20. https://doi.org/10.1177/1525822X05282260

Jacob, M. & Ní Fhloinn, E. (2019). A quantitative, longitudinal analysis of the impact of mathematics support in an Irish university. Teaching Mathematics and its Applications: An International Journal of the IMA, 38(4):216–229.

Johannesson, P., & Perjons, E. (2014). *An introduction to design science* (Vol. 10, pp. 978-3). Cham: Springer.

Johns, C. & Mills, M. (2021). Online mathematics tutoring during the COVID-19 pandemic: Recommendations for best practices. *Primus*, *31*(1), pp.99-117.

Johns, C., Byerley, C., Moore-Russo, D., Rickard, B., Oien, J., Burks, L., James, C., Mills, M., Heasom, W., Ferreira, M. & Mammo, B. (2021) Performance assessment for mathematics tutoring centres, *Teaching Mathematics and its Applications: An International Journal of the IMA*, 2021;, hrab032, https://doi.org/10.1093/teamat/hrab032

Johnston -Wilder, S. (ed.) (2018). Improving communication, engagement and resilience in STEM classrooms in South Africa [Blog]. Retrieved from http://blogs.warwick.ac.uk/icers

Johnston-Wilder, S., Baker, J.K., McCracken, A. & Msimanga, A. (2020). A toolkit for teachers and learners, parents, carers and support staff: Improving mathematical safeguarding and building resilience to increase effectiveness of teaching and learning mathematics. *Creative Education*, *11*(08), p.1418.

Johnston-Wilder, S., Brindley, J., & Dent, P. (2014). A survey of MA and MR among existing apprentices. *London: The Gatsby Foundation*.

Johnston-Wilder, S., Lee, C. (2010b) Developing Mathematical Resilience. *BERA Annual Conference,* 2010. University of Warwick.

Johnston-Wilder, S., Lee, C. (2010b). Mathematical Resilience. *Mathematics Teaching*, 218:38-41.

Johnston-Wilder, S., Lee, C., Brindley, J. & Garton, L. (2015). Developing mathematical resilience in school-students who have experienced repeated failure. *ICERI2015 Proceedings* (pp. 6358-6367). IATED.

Johnston-Wilder, S., Lee, C., Garton, E., & Brindley, J. (2014b). Developing coaches for mathematical resilience: level 2. In *Proceedings of 12thinternational conference of education, research and innovation*, pages 4457–4465

Johnston-Wilder, S., Lee, C., Garton, L., Goodlad, S., & Brindley, J. (2013). Developing Coaches for Mathematical Resilience. *ICERI 2013: 6th International Conference on Education, Research and Innovation, Seville*, 18-20 November 2013.

Johnston-Wilder, S. & Marshall, E. (2017). Overcoming affective barriers to mathematical learning in practice. In *IMA conference, Birmingham, July*, pages 10–12.

Johnston-Wilder, S., Pardoe, S., Almehrz, H., Evans, B., Marsh, J., & Richards, S. (2016). Developing teaching for MR in further education. In *9th International Conference of Education, Research and Innovation, ICERI2016, Seville*, pages 3019–3028.

Kamal, S. (2019). Research Paradigm and the philosophical foundations of a qualitative study. *International Journal of Social Sciences,* 4(3), pp. 100-230.

Kan, F. P., Raoofi, S., Rafiei, S., Khani, S., Hosseinifard, H., Tajik, F., Raoofi, N., Ahmadi, S., Aghalou, S., Torabi, F., Dehnad, A., Rezaei, S., Hosseinipalangi, Z., & Ghashghaee, A. (2021). A systematic review of the prevalence of anxiety among the general population during the COVID-19 pandemic. *Journal of affective disorders*, 293, 391-398.

Kohli, H., Wampole, D. & Kohli, A. (2021). Impact of online education on student learning during the pandemic. Studies in Learning and Teaching, 2(2), pp.1-11.

Kooken, J., Welsh, M., McCoach, D., Johnston-Wilder, S., & Lee, C. (2013). Measuring Mathematical Resilience: An application of the construct of resilience to the study of mathematics. *Paper presented at national conference of the American Educational Research Association*, San Francisco, CA.

Kyle, J. (2010). Affordability, Adaptability, Approachability and Sustainability, in C.M. Marr and M.J.Grove, eds. *Responding to the Mathematics Problem: The Implementation of Institutional Support Mechanisms*. Birmingham: Maths, Stats & OR Network, pp. 103-104.

Lau, N.T., Hawes, Z., Tremblay, P. & Ansari, D. (2022). Disentangling the individual and contextual effects of math anxiety: A global perspective. *Proceedings of the National Academy of Sciences*, *119*(7), p.e2115855119.

Lawson, D. (2021). A history of the development of the mathematics and statistics support community in the United Kingdom. Part 1: From alpha to sigma. *MSOR Connections*, 19(1), 5-12.

Lawson, D. (2000). Changes in the competency of a level students. *Measuring the mathematics problem*, pages 6–9.

Lawson, D. (2003). Changes in student entry competencies 1991–2001. *Teaching mathematics and its applications*, *22*(4), 171-175.

Lawson, D. (2015) Mathematics support at the transition to university, in Transitions in Undergraduate Mathematics Education, Eds: Grove, M., Croft, T., Kyle, J. and Lawson, D., University of Birmingham, pp. 39-56.

Lawson, D. A., Reed, J. & Tyrrell, S. E. (2002) A web-site for a Mathematics Support Centre. *Technology in Mathematics Teaching* (M. Borovcnik and H. Kautschitsch eds). Vienna, Austria: University of Klagenfurt

Lawson, D., Croft, A., & Halpin, M. (2003). Good practice in the provision of mathematics support centres. *LTSN Mathematics, Stats and OR Network*.

Lawson, D., Croft, T., & Halpin, M. (2001). Evaluating and enhancing the effectiveness of mathematics support centres. *Final report of a project funded by LTSN MSOR Centre*.

Lawson, D., Halpin, M. & Croft, T. (2001a). After the diagnostic test – what next? *MSOR Connections*, 1(3), pp. 19-23.

Lawson, D., Halpin, M. & Croft, T. (2001b). After the diagnostic test – what next? Part 2, *MSOR Connections*, 2(1), pp. 23-26

Lawson, D., Grove, M., & Croft, T. (2020). The evolution of mathematics support: a literature review. *International Journal of Mathematical Education in Science and Technology*, pages 1–31.

Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 Pisa 2003 participating countries. *Learning and individual differences*, 19(3):355–365.

Lee, C. & Johnston-Wilder, S. (2017). The construct of mathematical resilience. In *Understanding emotions in mathematical thinking and learning* (pp. 269-291). Academic Press.

Lee, C., & Johnston-Wilder, S. (2018). Getting into and staying in the Growth Zone. *Retrieved from https://nrich.maths.org/13491*.

Lee, S. & Lee, D.K. (2018). What is the proper way to apply the multiple comparison test? *Korean journal of anesthesiology*, *71*(5), pp.353-360.

Lignos, I. (2019). Using incoming data to monitor engagement and inform mathematics support interventions. *MSOR Connections*, 17(3).

Llorens S., Schaufeli W., Bakker A. & Salanova M. (2007). Does a positive gain spiral of resources, efficacy beliefs and engagement exist? *Computers in Human Behavior* 23: 825–41.

Lyons, I.M. & Beilock, S.L. (2012). Mathematics anxiety: Separating the math from the anxiety. *Cerebral cortex*, *22*(9), pp.2102-2110.

Mac an Bhaird, C., Morgan, T., & O'Shea, A. (2009). The impact of the mathematics support centre on the grades of first year students at the national university of Ireland maynooth. *Teaching Mathematics and its Applications: An International Journal of the IMA*, 28(3):117–122.

Mac an Bhaird, C., Fitzmaurice, O., Fhloinn, E. N., & O'Sullivan, C. (2013). Student non-engagement with mathematics learning supports. *Teaching Mathematics and Its Applications: International Journal of the IMA*, 32(4):191–205.

Mac an Bhaird, C., Mulligan, P. & O'Malley, J. (2021). Mathematics support centres' online presence: provision in Ireland and the UK in 2018. *Teaching Mathematics and Its Applications: International Journal of the IMA*, 40(3), pp.190-209.

Mac an Bhaird, C., Mulligan, P., O'Malley, J. & O'Neill, R. (2022). Access, Disability and Mature Student Opinion on Academic Mathematics Supports. *MSOR Connections*, *20*(3), pp.19-25.

Mac an Bhaird, C. & Lawson, D. (2012). How to set up a mathematics and statistics support provision. *Sigma–Centre of Excellence in Mathematics and Statistics Support*.

MacGillivray, H. (2009). Learning support and students studying mathematics and statistics. *International Journal of Mathematical Education in Science and Technology*, 40(4):455–472

MacGillivray, H. & Croft, T. (2011). Understanding evaluation of learning support in mathematics and statistics. *International Journal of Mathematical Education in Science and Technology*, 42(2), pp.189-212.

Macher, D., Paechter, M., Papousek, I., Ruggeri, K., Freudenthaler, H.H. & Arendasy, M., (2013). Statistics anxiety, state anxiety during an examination, and academic achievement. *British Journal of Educational Psychology*, 83(4), pp.535-549.

Macleod, S., C. Sharp, D. Bernardinelli, A. Skipp, and S. Higgins. 2015. *Supporting the Attainment of Disadvantaged Pupils: articulating Success and Good Practice: Research report*. London: Department for Education.

Maharaj, S. (2021). We are not visible minorities; we are the global majority. [Online] Available at: https://www.thestar.com/opinion/contributors/2021/02/09/we-are-not-visible-minorities-we-are-the-global-majority.html [Accessed 06 March 2023].

Mansell, W. (2015). Count us in: quantitative skills for a new generation. The British Academy. https://www. thebritishacademy. ac. uk/sites/default/files/Count-Us-In-Full-Report. pdf.

Marr, C.M. (2010) The University of St Andrews mathematics support centre: an appointment-based model. Responding to the Mathematics Problem: The Implementation of Institutional Support Mechanisms (C.M. Marr and M.J. Grove eds), MSOR Network, (see https://www.mathcentre.ac.uk/resources/uploaded/mathssupportvolumefinal.pdf), p. 23-28.

Marr, C. M., & Grove, M. J. (2010). Responding to the mathematics problem: The implementation of institutional support mechanisms. *Birmingham: Maths, Stats & OR Network*.

Marshall, E.M., Wilson, D.A. & Mann, V.E. (2018). Evaluating the effectiveness of maths anxiety awareness workshops. *Journal of Learning Development in Higher Education*.

Marshall, E. M., Staddon, R. V., Wilson, D. A., & Mann, V. E. (2017). Addressing MA and engaging students with mathematics within the curriculum. *MSOR Connections*, 15(3).

Marshall, E. M., Wilson, D. A., & Mann, V. E. (2016). Attitudes and anxiousness about mathematics. In *Brave New World: Proceedings of the CETL MSOR Conference*, pages 66–74.

Matthews, K.E., Belward, S., Coady, C., Rylands, L., Simbag, V., Adams, P., Peleaz, N., Thompson, K., Parry, M. & Tariq, V. (2012). *The state of quantitative skills in undergraduate science education: findings from an Australian study*. Australian Government, Office for Learning and Teaching.

Matthews, J., Croft, T., Lawson, D., & Waller, D. (2013). Evaluation of mathematics support centres: a literature review. *Teaching Mathematics and Its Applications: International Journal of the IMA*, 32(4):173–190.

Maxwell, J. (2016). Expanding the history and range of mixed methods research. *Journal of Mixed Methods Research,* pp. 12-27.

Mo, Y. & Singh, K. (2008). Parents' relationships and involvement: Effects on students' school engagement and performance. RMLE online, 31(10), pp.1-11.

Morse, J. M. (1991). Approaches to qualitative-quantitative methodological triangulation. *Nursing research*, *40*(2), 120-123.

Mullen, C., Pettigrew, J., Cronin, A., Rylands, L. & Shearman, D. (2021). Mathematics is different: student and tutor perspectives from Ireland and Australia on online support during COVID-19. *Teaching Mathematics and Its Applications: International Journal of the IMA*, *40*(4), pp.332-355.

Mullen, C., Pettigrew, J., Cronin, A., Rylands, L. & Shearman, D. (2022). The rapid move to online mathematics support: changes in pedagogy and social interaction. *International Journal of Mathematical Education in Science and Technology*, *53*(1), pp.64-91.

Murdock, M. (1982). Teaching to overcome statistics anxiety. *Proceedings of Statistical Education-American Statistical Association*, 92-93.

Muslimin, A.I. & Harintama, F. (2020). Online learning during pandemic: Students' motivation, challenges, and alternatives. *Loquen: English Studies Journal*, 13(2), pp.60-68.

Nardi, E. & Steward, S. (2003). Is mathematics tired? A profile of quiet disaffection in the secondary mathematics classroom. *British Educational Research Journal*, 29(3):345–366.

Newman, L.A., Madaus, J.W., Lalor, A.R. & Javitz, H.S. (2021). Effect of accessing supports on higher education persistence of students with disabilities. Journal of Diversity in Higher Education, 14(3), p.353.

Newman I, 2000. *A conceptualization of mixed methods: A need for inductive/deductive approach to conducting research*. Annual meeting of the American Educational Research Association. 2000, April 24–25. New Orleans, LA.

Nickerson, C. (2023). The Yerkes-Dodson Law of Arousal and Performance. [Online] Available at: https://simplypsychology.org/what-is-the-yerkes-dodson-law.html [Accessed 09 March 2023].

Ní Fhloinn, E. (2009). The role of student feedback in evaluating mathematics support centres. In Green, D. (Ed) *Proceedings of the CETL MSOR Conference, 2009,* pp 94-98.

Ní Fhloinn, E., Fitzmaurice, O., Mac an Bhaird, C., & O'Sullivan, C. (2014). Student perception of the impact of mathematics support in higher education. *International Journal of Mathematical Education in Science and Technology*, *45*(7), 953-967.

Ní Fhloinn, E., Fitzmaurice, O., Mac an Bhaird, C. & O'Sullivan, C. (2016). Gender differences in the level of engagement with mathematics support in higher education in Ireland. *International Journal of Research in Undergraduate Mathematics Education*, 2(3), pp.297-317.

Ní Fhloinn, E., & Fitzmaurice, O. (2021). Challenges and opportunities: Experiences of mathematics lecturers engaged in emergency remote teaching during the COVID-19 pandemic. *Mathematics*, *9*(18), p. 2303. https://doi.org/10.3390/math9182303

Norris, E. (2012). *Solving the mathematics problem: international perspectives on mathematics education*. Royal Society for the encouragement of Arts, Manufactures and Commerce.

Office, National Audit (2007). *Staying the course: The retention of students in higher education*, volume 616. The Stationery Office.

Olsen, W. (2004). Triangulation in social research: qualitative and quantitative methods can really be mixed. *Developments in sociology*, *20*, 103-118.

Nyhagen, L. (2022). Reducing the BAME degree awarding gap at Loughborough University. [Online] Available at: https://www.lboro.ac.uk/schools/social-sciences-humanities/about/equality-diversity-inclusion/edi-insights/reducing-the-bame-gap/ [Accessed 21 September 2022].

Office for Students (2020) Access and participation plan 2020-21 to 2024-25. Available at https://apis.officeforstudents.org.uk/accessplansdownloads/2024/CoventryUniversity_APP_2020-21_V1_10001726.pdf, Accessed 10 June 2020.

Onwuegbuzie, A.J., Da Ros, D. & Ryan, J.M. (1997). The Components of Statistics Anxiety: A Phenomenological Study. Focus on Learning Problems in mathematics, 19(4), pp.11-35.

Onwuegbuzie, A.J. & Wilson, V.A., (2003). Statistics Anxiety: Nature, etiology, antecedents, effects, and treatments--a comprehensive review of the literature. Teaching in higher education, 8(2), pp.195-209.

Onwuegbuzie, A. J. (2004). Academic procrastination and statistics anxiety. *Assessment and Evaluation in Higher Education*, 29(1):3–19.

O'Sullivan, L., Casey, D. & Crowley, J. (2021). Asynchronous online mathematics learning support: an exploration of interaction data to inform future provision. *Teaching Mathematics and its Applications: An International Journal of the IMA*, *40*(4), pp.317-331.

O'Sullivan, C., Mac an Bhaird, C., Fitzmaurice, O., & Ní Fhloinn, E. (2014). *An Irish Mathematics Learning Support Network (IMLSN) report on student evaluation of mathematics learning support: Insights from a large scale multi-institutional survey*. Ireland. Retrieved from http://www.imlsn.ie/index.php/imlsn-reports/imlsn-reports

Owen, A., Samuels, P., Wrightham, M., Leckenby, B., & Gilchrist, M. (2011). A pilot for a shared online statistics advisory service. *MSOR Connections*, 11(3).

Pajares, F. & Urdan, T. (1996). Exploratory factor analysis of the MA scale. *Measurement and Evaluation in Counseling and Development*.

Panesar, L. (2017). Academic support and the BAME attainment gap: using data to challenge assumptions. *Spark: UAL Creative Teaching and Learning Journal*, *2*(1), 45-49.

Para, T. & Johnston-Wilder, S. (2023). Addressing Mathematics Anxiety: A Case Study in a High School in Brazil. *Creative Education*, *14*(2), pp.377-399.

Parsons, B., & Johnston, H. (2022). Understanding student preferences for one to one writing appointments post-pandemic. *Journal of Learning Development in Higher Education*, (24).

Patel, C. & Rossiter, A. (2010), August. Student engagement and Non-engagement with Mathematics and Statistics Support. In *CETL-MSOR Conference,* 2009.

Patel, C. & Rossiter, J.A. (2011). Encouraging engagement with mathematics through course change and additional support. *Proc. Mathematical Education of Engineers, Loughborough*.

Payne, S. L., Kleine, K. L., Purcell, J., & Carter, G. R. (2005). Evaluating academic challenge beyond the nsse. *Innovative Higher Education*, 30(2):129–146.

Pell, G. & Croft, T. (2008). Mathematics support—support for all? *Teaching mathematics and its applications*, 27(4):167–173.

Perkin, G., Croft, T., & Lawson, D. (2013). The extent of mathematics learning support in UK higher education—the 2012 survey. *Teaching Mathematics and its Applications: An International Journal of the IMA*, 32(4):165–172.

Phellas, C., Bloch, A. & Seale, C. (2011). Structured methods: interviews, questionnaires and observation... In: *Researching Society and Culture.* s.l.:s.n., pp. 191-205.

Primi, C. & Chiesi, F. (2018). The role of MA and statistics anxiety in learning statistics. In 10th International Conference on Teaching Statistics, Kyoto, Japan. Retrieved from https://iase-web. org/icots/10/proceedings/pdfs/ICOTS10_5E2. Pdf

Ramirez, G., Shaw, S.T. & Maloney, E.A. (2018). Math anxiety: Past research, promising interventions, and a new interpretation framework. *Educational psychologist*, *53*(3), pp.145-164.

Razak, R.A. (2020). Overcoming math anxiety and developing mathematical resilience via e-learning. In *Understanding Digital Industry* (pp. 404-406). Routledge.

Reason R., Terenzini P., & Domingo R. (2006) First things first: Developing academic competence in the first year of college, Research in Higher Education 47(2): 149–75.

Reeve, J. & Lee, W. (2014). Students’ classroom engagement produces longitudinal changes in classroom motivation. *Journal of Educational Psychology*, 106(2):527.

Reeve, J. & Tseng, C. M. (2011). Agency as a fourth aspect of students' engagement during learning activities. *Contemporary Educational Psychology*, 36(4):257–267.

Rendulic, P. & Terrell, S. (2000). Anxiety toward statistics and the use of computers: a study of graduate level education majors. *Journal of Computing in Higher Education*, 11(2):104–120.

Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale. *Journal of Counseling Psychology*, 19, 551-554.

Rimm-Kaufman, S. E., Larsen, R. A., Baroody, A. E., Curby, T. W., Ko, M., Thomas, J. B., ... & DeCoster, J. (2014). Efficacy of the responsive classroom approach: Results from a 3-year, longitudinal randomized controlled trial. *American Educational Research Journal*, *51*(3), 567-603.

Saeed, S. & Zyngier, D. (2012). How motivation influences student engagement: a qualitative case study. *Journal of Education and Learning*, 1(2):252–267.

Schaufeli, W. B., Salanova, M., Gonz´alez-Rom´a, V., & Bakker, A. B. (2002). The measurement of engagement and burnout: A two sample confirmatory factor analytic approach. *Journal of Happiness studies*, 3(1):71–92.

Schult, J., Mahler, N., Fauth, B., & Lindner, M. A. (2022). Long-term consequences of repeated school closures during the COVID-19 pandemic for reading and mathematics competencies. In *Frontiers in Education* (Vol. 13). Frontiers Media SA.

Schürmann, M. & Schaper, N. (2022). Mathematische Lernzentren als Unterstützungsmaßnahmen in der Studieneingangsphase. In: Hochmuth, R., Biehler, R., Liebendörfer, M., Schaper, N. (eds) Unterstützungsmaßnahmen in mathematikbezogenen Studiengängen. Konzepte und Studien zur Hochschuldidaktik und Lehrerbildung Mathematik. Springer Spektrum, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-64833-9_20

Schürmann, M., Gildehaus, L., Liebendörfer, M., Schaper, N., Biehler, R., Hochmuth, R., Kuklinski, C. & Lankeit, E. (2021) , Mathematics learning support centres in Germany—an overview, *Teaching Mathematics and its Applications: An International Journal of the IMA*, Volume 40, Issue 2, June 2021, Pages 99–113, https://doi.org/10.1093/teamat/hraa007

Schwandt, T. A. (2000). Three epistemological stances for qualitative inquiry: Interpretivism, hermeneutics, and social constructionism. In: N. K. Denzin & Y. S. Lincoln, eds. *Handbook of qualitative research.* s.l.: Sage Publication Inc., p. 210.

Scott, J. (2023). *All pupils in England to study maths until 18 under Rishi Sunak's 'new mission'.* [Online]
Available at: https://news.sky.com/story/all-pupils-in-england-to-study-maths-until-18-under-rishi-sunaks-new-mission-12779266 [Accessed 20 02 2023].

Skaalvik, E.M. & Rankin, R.J. (1994). Gender differences in mathematics and verbal achievement, self-perception and motivation. *British Journal of Educational Psychology*, *64*(3), pp.419-428.

Siegel, D. (2010). *PsychAlive.* [Online] Available at: https://www.psychalive.org/minding-the-brain-by-daniel-siegel m-d-2/ [Accessed 11th June 2021].

Singh, G. (2011). *Black and minority ethnic (BME) students' participation in higher education: improving retention and success. A synthesis of research evidence*. Higher Education Academy.

Smith, A. (2004). *Making Mathematics Count.* The report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education London: DES

Smith, J. P. & Naylor, R. A. (2001). Dropping out of university: a statistical analysis of the probability of withdrawal for UK university students. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 164(2):389–405.

Smith, S. 2019. *The attainment and experience of our lbu bame students - what do colleagues and student perspectives tell us? (And what can we do about it?)*. In NUCCAT Symposium, 10 May 2019, University of Derby, UK. (Unpublished).

Society, London Mathematical (1995). *Tackling the mathematics problem*. Mathematical Society.

(Solomon et al., 2010) Solomon, Y., Croft, T., & Lawson, D. (2010). Safety in numbers: mathematics support centres and their derivatives as social learning spaces. *Studies in Higher Education*, 35(4):421–431.

Stripp, C. (2018). Mei-media-release-level-3-qualifications-august-2018. https:
//mei.org.uk/files/pdf/MEI-media-release-level-3-qualifications-August-2018. pdf/.

Sutherland, R. & Pozzi, S. (1995). *The changing mathematical background of undergraduate engineers: A review of the issues*. Engineering Council London.

Symonds, R. (2009). *Evaluating student engagement with mathematics support* (Doctoral dissertation, Loughborough University).

Symonds, R., Lawson, D., & Robinson, C. (2008). Promoting student engagement with mathematics support. *Teaching Mathematics and Its Applications: International Journal of the IMA*, 27(3):140–149.

Tashakkori, A. & Teddlie, C. (2003). Issues and dilemmas in teaching research methods courses in social and behavioural sciences: US perspective. *International journal of social research methodology,* pp. 61-77.

Terrell, S. R. & Edmonds, W. A. (2017). *Mixed-methods research methodologies.* [Online] Available at: https://education.nova.edu/summer/2017sessionmaterials/Elective_Mixed-Methods_Edmonds_Terrell.pdf
[Accessed 6 6 21].

The Royal Sciences and the British Academy (2022). *The importance of promoting Core Maths as practical and valuable qualifications.* https://royalsociety.org/-/media/policy/Publications/2022/2022-01-26-core-maths-joint-statement.pdf

Thomas, L. (2005). *Widening participation in post-compulsory education*. A&C Black.

Thomas, L. (2012). Building student engagement and belonging in higher education at a time of change. *Paul Hamlyn Foundation*, 100:1–99.

Thornton, S., Statton, J., & Mountzouris, S. (2012). Developing mathematical resilience among aboriginal students. *Mathematics Education Research Group of Australasia*.

Trigwell, K. & Prosser, M. (1991). Improving the quality of student learning: the influence of learning context and student approaches to learning on learning outcomes. *Higher education*, *22*(3), pp.251-266.

Trott C., & Chinn, S. (2016). The hidden maths content in HE courses: A survey. Presentation given to the British Dyslexia Association International Conference, Moving forward: Challenges and transitions. Oxford, UK.

Tsang, S., Royse, C. F. & Terkawi, A. S. (2017). Guidelines for developing, translating, and validating a questionnaire in perioperative and pain medicine. *Saudi Journal of Anaesthesia,* 11(1), pp. 80-89.

Universities UK and NUS (National Union of Students) (2019) Black, Asian and Minority Ethnic Student Attainment at UK Universities: #closingthegap. Accessed 21 May 2021. www.universitiesuk.ac.uk/policy-and-analysis/reports/Documents/2019/bame-student-attainment-ukuniversities-closing-the-gap.pdf

University Writing Center, A. S. U. (2014). *A short guide for conducting research interviews.* [Online]. Available at: https://www.csus.edu/indiv/o/obriene/art116/readings/guide%20for%20conducting%20interviews.pdf. [Accessed Thursday March 2022].

Wang, M.-T. & Degol, J. (2014). Staying engaged: Knowledge and research needs in student engagement. *Child development perspectives*, 8(3):137–143.

Wang, M.T., Fredricks, J.A., Ye, F., Hofkens, T.L. & Linn, J.S. (2016). The math and science engagement scales: Scale development, validation, and psychometric properties. Learning and Instruction, 43, pp.16-26.

Wang, Z., Lukowski, S.L., Hart, S.A., Lyons, I.M., Thompson, L.A., Kovas, Y., Mazzocco, M.M., Plomin, R. & Petrill, S.A. (2015). Is math anxiety always bad for math learning? The role of math motivation. *Psychological science*, *26*(12), pp.1863-1876.

Wilshire, C. (2017). The problem of bias in behavioural intervention studies: Lessons from the PACE trial. *Journal of health psychology,* pp. 1128-1133.

Wolf, A. & Jenkins, A. (2002). *The growth of psychometric testing for selection: why has test use increased, will growth continue, and what does this mean for education?* (No. 29). Centre for the Economics of Education, London School of Economics and Political Science.

Wood, L. (2010). Graduate capabilities: putting mathematics into context. *International Journal of Mathematical Education in Science and Technology*, 41(2):189–198.

Yager, G. G., & Wilson, F. R. (1986). Ten suggestions on teaching research to counseling students. Paper presented at the meeting of the North Central Association for Counselor Education and Supervision, Kansas City, MO.

Yurtcu, M., & Dogan, N. (2015). Scaling with Paired Comparison Method for Reasons for Mathematics Anxiety of Secondary School Students. *Procedia Social and Behavioral Sciences*, 197, 851−857. https://doi.org/10.1016/j.sbspro.2015.07.209

Zakaria, E. & Nordin, N. M. (2008). The effects of MA on matriculation students as related to motivation and achievement. *Eurasia Journal of Mathematics, Science and Technology Education*, 4(1).

Zepke, N. & Leach, L. (2010). Improving student engagement: Ten proposals for action. *Active learning in higher education*, 11(3):167–177.

Appendices

Appendix 1 – Mathematics Resilience and Anxiety questionnaire

The purpose of the study is to explore reasons for student non-engagement with Mathematics and Statistics Support (MSS) and then to develop an intervention to address this non-engagement. In particular, mathematical anxiety (negative emotional reaction to mathematics that can be debilitating) may inhibit engagement with **sigma** (Coventry University's MSS centre) and mathematical resilience (a positive stance to learning mathematics) may promote such engagement. This questionnaire will provide further insight into this.

For more information, please click the following link: Further Information

I have downloaded the Participant Information sheet, and understood the information it provides about this study, particularly that I am able to withdraw my information until December 31st 2021, at which point the data will be fully anonymised. I agree to take part in this questionnaire survey. I confirm that I am aged 18 or over. I agree to take part in this survey. □ Required

By ticking this box, you are giving your informed consent to participate in this research

Please enter your full name. Your data will be anonymised as soon as possible and will be kept securely and confidentially until then. □ Required

Please enter your **Student ID number**. Your data will be anonymised as soon as possible and will be kept securely and confidentially until then. □ *Required*

Please select your **year** of study □ *Required*

1st year undergraduate

Postgraduate

2nd year undergraduate

Staff

3rd year or above undergraduate

Other

Please state your course title □ *Required*

Are you happy to be contacted further about possible participation in a related online questionnaire and/or focus group/interview? You can opt out of this contact at any time.

 Required

Yes

No, not right now

I would only be happy to hear another questionnaire

Are you happy to be contacted further about possible participation in a related online intervention? You can opt out of this contact at any time. *Required*

Yes

No, not right now

Did the amount of mathematics you expected in the course have an effect on your degree choice?

Yes

No

Were you looking for a degree that involved:

A lot of mathematics

A moderate amount of mathematics

A minimal amount mathematics

No mathematics

Think about the mathematics in your degree. What areas do you find particularly hard, if any?

Think about the mathematics in your degree. What areas do you find particularly easy, if any?

Mathematics anxiety scale

1. It wouldn't bother me at all to take more maths classes.
2. I have usually been at ease during maths tests.
3. I have usually been at ease in maths courses.
4. I usually don't worry about my ability to solve maths problems.
5. I almost never get uptight while taking maths tests.
6. I get really uptight during maths tests.
7. I get a sinking feeling when I think of trying hard maths problems.
8. My mind goes blank and I am unable to think clearly when working on mathematics.

9. Mathematics makes me feel uncomfortable and nervous.
10. Mathematics makes me feel uneasy and confused.

Mathematical resilience scale

1. Maths is very helpful no matter what I decide to study.
2. Struggle is a normal part of working on Maths.
3. If someone is not good at Maths, there is nothing that can be done to change that.
4. Maths can be learned by anyone.
5. Everyone struggles with Maths at some point.
6. Maths is essential for my future.
7. If someone is not a Maths person, they won't be able to learn much Maths.
8. Good Mathematicians experience difficulties when solving problems.
9. People who work in Maths-related fields sometimes find Maths challenging.
10. People are either good at Maths or they aren't.
11. Everyone makes mistakes at times when doing Maths.
12. Maths will be useful to me in my life's work.
13. People in my peer group sometimes struggle with Maths.
14. Everyone's Maths ability is determined at birth.
15. People who are good at Maths may fail a hard Maths test.
16. Knowing Maths contributes greatly to achieving my goals.
17. Having a solid knowledge of Maths helps me understand more complex topics in my field.
18. Some people cannot learn Maths.
19. Learning Maths develops good thinking skills that are necessary to succeed in any career.
20. Making mistakes is necessary to get good at Maths.
21. Thinking mathematically can help me with things that matter to me.
22. Only smart people can do Maths.
23. It would be difficult to succeed in life without Maths.

To gain a deeper understanding of the effects of mathematics resilience and anxiety, I would like to compare your score from this questionnaire to your "BMSQS Quantitative Skills Quizzes" result Are you happy for me to access your score when it becomes available? □ Required

Yes

No

Not applicable

Scoring systems for MA and MR scales

Strongly Agree 5, Agree 4, Neither Agree nor Disagree 3, Disagree 2, Strongly Disagree 1

was used by default for each question. However, some questions were negatively worded, and as such, they were reverse coded upon inputting into SPSS. In these cases, a scoring system of Strongly Agree 1, Agree 2, Neither Agree nor Disagree 3, Disagree 4, Strongly Disagree 5 was used. The mean of an individual's score was then calculated by adding up their scores and dividing by the number of items in each questionnaire. Items 1-5 were reverse-coded in the MA scale, whilst items 3, 7, 10, 14, 18 and 22 were reverse-coded in the MR scale.

Appendix 2 – Engagement with Mathematics and Statistics questionnaire

Engagement with Mathematics and Stats Support

Page 1: Participant Information Sheet

The purpose of the study is to explore reasons for student engagement with Mathematics and Statistics Support (MSS), whilst developing an intervention to address non-engagement. The following questionnaire will provide further insight into this

For more information, please click the following link:

I have downloaded and read the **Participant Information sheet,** understanding the information it provides about this study, particularly that I am able to withdraw my information until December 31st 2021, at which point the data will be fully anonymised I agree to take part in this questionnaire survey I confirm that I am aged 18 or over I agree to take part in this survey *Required*

By ticking this box, you are giving your informed consent to participate in this research.

Please state your full name. Your data will be anonymised as soon as possible and will be kept securely and confidentially until then *Required*

Please enter a response that only contains letters

Please state your student ID number. Your data will be anonymised as soon as possible and will be kept securely and confidentially until then *Required*

Please enter a whole integer

1. How would you rate your level of competency in mathematics/statistics?

Excellent

Good

Average

Unsatisfactory

Poor

2. Describe what **you** think mathematics/statistics anxiety is in no more than six words
3. Describe what **you** think mathematics/statistics resilience is in no more than six words.
4. Describe what you think mathematics and stats support is.

5. Who do you think mathematics and stats support is for?

sigma is Coventry University's mathematics and stats support service.

6. Have you used any of the following services that **sigma** provides**? Tick as many as you like** *Required*

- Drop-in centre at the library Workshop
- Pre-booked appointment (online)
- I have not used any of **sigma**'s services Resources from the **sigma** website Email support
- Online drop-in centre
- Pre-booked appointment (face-to-face)

7. What was your main reason for engaging with **sigma**?
8. What would encourage you to engage with **sigma**?
9. Do you have any ideas of how to encourage more students to use **sigma**'s services?
10. Have you ever considered dropping out of university because of difficulties with the mathematical or statistical elements of your course? *Required*

Yes

No

11. Did the availability of mathematics and stats support influence your decision not to drop out?

Yes

No

12. Some people have indicated that they are reluctant to engage with mathematics and stats support because of emotional reasons such as being afraid that others will look down on them for seeking help; feeling uncomfortable asking for help; thinking their questions are so basic it will be embarrassing, etc. On a scale of 1-5 where **1 is not at all and 5 is very much**, how much do these kind of reasons apply to you?

1

2

3

4

5

Please indicate which reasons affect you most.

13. Which of these statements most closely represents your feelings about the amount of mathematics/stats within your course:

I wish there was more mathematics/stats in my course

The amount of mathematics/stats in my course is about right I wish there was less mathematics/stats in my course

I wish there was no mathematics/stats in my course

14. If you were struggling with the mathematics/stats in your course, please rank the following in the order of what you might do about it **(with 1 being the option you would choose first)**

Please don't select more than 1 answer(s) per row.

Do nothing, just try to get by as best I can

Talk to other students, and see if they can help

Ask one of my lecturers/tutors for extra help

Look on the internet or in books

Visit the University's mathematics and stats support service

Are there any other things you might do?

Would you be happy to be contacted about participating in a focus group or interview to explore these topics further? (Note that you can opt out of communication at any point by *) *Required*

Have you completed the mathematics resilience/anxiety questionnaire? *Required*

Yes

No

Do you consent for your data from this questionnaire to be matched with your results from there? All your data will be secured anonymously once the matching has been completed.

Yes

No

The link for the mathematics anxiety/resilience is below Please feel free to complete it after the completion of this questionnaire Your participation will contribute to the improving of **sigma**'s services for **all** students **Please remember to read the participant information sheet for the mathematics anxiety/resilience questionnaire.**

I will follow this link once I have submitted my answers for this questionnaire

I do not want to complete another survey at this point in time.

Thank you for your participation in this survey and for the information you have provided. Your responses will contribute to our analyses of student engagement with mathematics and statistics support and suggest new lines of approach to the data. Your help is very much appreciated.

Appendix 3 – Example of Informed Consent form

INFORMED CONSENT FORM:

An Investigation of Student Engagement and Non-engagement with Mathematics and Statistics Support Services

You are invited to take part in this research study for the purpose of collecting data on engagement with mathematics and statistics support services. The purpose of this intervention is to help increase your mathematical resilience level.

Before you decide to take part, you must **read the accompanying Participant Information Sheet.**

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.

Once you have submitted your consent form, the researcher will allocate you a Participant Number which is how you will be referred to in any notes for the purpose of protecting your identity in any research outputs.

If you are happy to participate, please confirm your consent by circling YES against each of the below statements and then signing and dating the form as participant.

1	**I confirm that I have downloaded, read and understood the Participant Information Sheet for the above study and have had the opportunity to ask questions**	**YES**	**NO**
2	**I understand my participation is voluntary and that I am free to withdraw my data, without giving a reason, by contacting the lead researcher and the Research Support Office at any time until the date specified in the Participant Information Sheet**	**YES**	**NO**
3	**I understand that the researcher will assign me a Participant Number, by which I will be referred to in any notes taken**	**YES**	**NO**
4	**I understand that all the information I provide will be held securely and treated confidentially**	**YES**	**NO**
5	**I am happy for the information I provide to be used in academic papers and other formal research outputs**	**YES**	**NO**
6	**I agree to take part in the above study**	**YES**	**NO**

Thank you for your participation in this study. Your help is very much appreciated Please send this form to the researcher, Farhana Gokhool, over email ([removed]).

Participant's Name	**Date**	**Signature**
Researcher	**Date**	**Signature**

Appendix 4 –Example of Participant Information Sheet

PARTICIPANT INFORMATION SHEET

You are being invited to take part in research on engagement with mathematics and statistics support (MSS) services, namely on **reducing mathematics anxiety by increasing mathematical resilience.**

There will be NO assessments to analyse mathematical competency.

Farhana Gokhool, a PhD student at Coventry University, is leading this research. Before you decide to take part, it is important you understand why the research is being conducted and what it will involve Please take time to read the following information carefully.

Please note you must be over the age of 18 to participate in this study.

If you suffer from clinical anxiety, participating in this intervention may be triggering and further support from mental health specialists may be needed, though complete care will be taken for this to not occur.

What is the purpose of the study?

The purpose of the study is to explore reasons for student non-engagement with MSS and then to develop an intervention to address this non-engagement. In particular, mathematical anxiety (negative emotional reaction to mathematics that can be debilitating) may inhibit engagement with **sigma** and mathematical resilience (a positive stance to learning mathematics) may promote such engagement.

This intervention aims to help you increase your mathematical resilience/decrease your mathematics anxiety. There will be no requirement to answer any mathematics/stats questions in the intervention, nor will there be an assessment.

Why have I been chosen to take part?

You are invited to participate in this study because you are over the age of 18 and enrolled on a course with mathematical/statistical content.

What are the benefits of taking part?

Increasing your mathematics resilience / reducing your mathematical anxiety may also help you to succeed on your course at the University By sharing your experiences with us, you will be helping Farhana Gokhool and Coventry University to better understand the reasons why students choose to not engage with MSS and to improve our services to make them more accessible / relevant to more students.

Are there any risks associated with taking part?

This study has been reviewed and approved through Coventry University's formal research ethics procedure. There are no significant risks associated with participation. However, this intervention will deal with mathematics anxiety, a topic which may be triggering to some. If you suffer from clinical anxiety, participating in this study may worsen anxiety.

Do I have to take part?

No – it is entirely up to you. If you do decide to take part, please keep this Information Sheet and complete the Informed Consent Form to show that you understand your rights in relation to the research, and that you are happy to participate Please note down your participant number (which is on the Consent Form) and provide this to the lead researcher if you seek to withdraw from the study at a later date. You are free to withdraw your information from the project data set at any time until the data have been fully anonymised (after this point we cannot identify your data to remove them); such anonymization will have taken place by **December 31st 2021** You should note that your data may be used anonymously in the production of formal research outputs (e.g., journal articles, conference papers, theses and reports) prior to this date and so you are advised to contact the University at the earliest opportunity should you wish to withdraw from the study. To withdraw, please contact the lead researcher (contact details are provided below), 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 to withdraw. Your decision to not to take part, will not affect you in any way.

What will happen if I decide to take part?

You will attend weekly sessions covering what mathematics resilience/anxiety is, as well as equipping you with methods to overcome mathematics anxiety and increasing your mathematics resilience. Each session is optional but maximum benefit will be reached by attending all sessions. Depending on regulations in place at the time of the sessions, these sessions will be delivered over Microsoft Teams or face-to-face and will run for a maximum of five sessions of fifty-minutes each. You will be asked to complete the mathematics resilience/anxiety questionnaire again after the intervention, which will take less than ten minutes. The researcher will make reflective notes after each session of the intervention, recording key issues discussed. These notes will only refer to your participant number, which will be stored safely.

There will be no requirement to answer any mathematics/stats questions, nor will you be tested on your level of mathematical competency.

Your student ID will be used to connect the results of this study to any other study you have participated in with this researcher. It will also be connected to your University data such as data to do with your course and your demographic data. Any findings will only be used for the purpose of this research and all information will be kept safely.

Data Protection and Confidentiality

Your data will be processed in accordance with the General Data Protection Regulation 2016 (GDPR) and the Data Protection Act 2018. 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 rather than by name. If you consent to being audio recorded, all recordings will be destroyed once they have been transcribed. Your data will only be viewed by the researcher/research team. All electronic data will be stored on a password-protected computer file on Coventry University's OneDrive. All paper records will be stored in a locked filing cabinet in Whitefriars building. Your consent information will be kept separately from your responses in order to minimise risk in the event of a data breach. The lead researcher will take responsibility for data destruction and all collected data will be destroyed on or before 31st March 2023.

Data Protection Rights

Coventry University is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance with the General Data Protection Regulation and the Data Protection Act 2018. You also have other rights including rights of correction, erasure, objection, and data portability. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please ([removed]). Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer.

What will happen with the results of this study?

The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will always be made anonymous in any formal outputs unless we have your prior and explicit written permission to attribute them to you by name. The results will contribute to a PhD thesis.

Making a Complaint

If you are unhappy with any aspect of this research, please first contact the lead researcher, Farhana Gokhool, ([removed]). If you still have concerns and wish to make a formal complaint, please write to: ([removed]).

In your letter please provide information about the research project, specify the name of the researcher and detail the nature of your complaint

Appendix 5 – Interview Guide

Have you used **sigma** before?

Students who have engaged with sigma

What have you used?

Why did you first decide to engage with **sigma**?

What made you continue accessing support (to those who repeat visited)?

What would you say are the three best things about **sigma**?

Is there anything we can do to improve our services?

How did you hear about **sigma**?

Do your peers use **sigma**?

What do you think stops students from accessing support?

How did you overcome this when you needed to access support?

How would you encourage other students to engage with mathematics and stats support?

Students who have not engaged with sigma

What stops you from accessing mathematics and stats support?

What would encourage you to use **sigma** if you needed to?

Do you feel anxious when you know you have to do some mathematics or stats?

What do you think is the relationship between mathematics/statistics anxiety and not engaging with **sigma**?

If you were struggling with mathematics or stats, what would you do about it?

All students

How did you feel about mathematics at school?

What do you think made you feel this way?

What were your family and friends' attitudes about mathematics?

Is there a difference between asking for help in your first and third year of university?

Do you think culture affects perception?

Do you think others' attitudes affect someone's attitudes about mathematics? Why?

Do you still feel the same about mathematics now? Why?

What do you think mathematics and stats support is?

Who is mathematics and stats support for?

If someone felt anxious about mathematics/stats, do you think it would make them more or less likely to engage with mathematics and stats support?

Why?

How could we encourage anxious students to visit?

Appendix 6 – Lesson Plans

Intervention lesson plan 1

Cameras have to be on - give students time for this

Aim: Create community for leaving

Time to complete questionnaire

Outcomes: What is a safe environment?

What does the hand model of the brain show?

What is Mathematics Anxiety/Mathematics Resilience (MA/MR?)

5 mins: Introduction to session and purpose of intervention Emphasis on creating atmosphere that is safe and free of ridicule Explain MA/MR

5 mins: Explanation of "rules" No mathematics

Hand up if question

If "triggered", discussion stops. Can message me separately in chat or turn camera off

5-10 mins - Any questions Opportunity to email questions instead Ask students for their rules

15 mins - Hand model of brain (logic no longer influences emotion)

30 mins - Calling on Students' own knowledge (bio students e.g.)

Ask students for their real-life experience feeling panic (not to do with Mathematics)

Now ask if they're had this experience with mathematics, in previous schools/when doing homework/shopping/gaming (monopoly example)

Remind students they can turn off camera whenever they want

10 mins - Bringing session back to feel safe

Rest of session Remind students this is something they can be equipped to deal with -tools will be given in next session

Not their fault!!

Remind students about **sigma**

Remind students they can email in

Remind students about available mental health support

Brief intro to breathing techniques/focusing on senses to get out of panic mode

Intervention lesson plan 2

Aim: To open discussion about the growth zone model and using RAG zones

To reflect on experience with mathematics

Outcomes:

What is the growth Zone model?

How does using RAG zones help when completing a mathematics activity?

What helps you exit the red zone / stay in the amber zone for longer?

10 mins Recap of rues + last session

15 mins - Growth Zone model explanation

Words in each zone (given by students) to show what each zone feels like to them

"What does each zone feel like to you?" Experiences

Reiteration that recognition of what zone students are in is key RAG

2 mins - constant evaluation of what zone students are in Pause if any student is in the red

15 mins - if any student is in red or green zone, what would help you move towards amber?

Share

Zin task:

What did you do?

What strategies did you use?

How did you feel?

What helped and hindered you doing this task?

What have you leaned?

How does zin remind you of problems in everyday life?

How do you feel now using RAG?

10 mins - Feedback on SESSION

What will happen in further sessions?

Directed to **sigma** + mental health support

Can recommend to other students

Reiteration that red zone is temporary and it can be equated to feeling stupid

Intervention lesson plan 3

Aim: To share methods on how students can increase MR/ decrease mA

Outcomes:

Recap of hand-model

Introduction of ladder model

How to switch off the alarm

5 mins: Reintroduction of RAG

5 mins: Recap of hand-model

15 mins: Discussion around how "alarm" can be switched off (with student input)

5 mins: Ladder model

10 mins: Sharing / demonstration of **sigma** resources

10 mins: Feedback from students - What helped + what didn't help

10 mins: what next session will be about (potentially?)

Refer to mental health services

General chat about mathematics in course that is difficult/easy if all students are on green

Last two sessions will be in case first 3 sessions run over and/or if students want further discussion

Time will be allotted for students that have consented to answer it

Appendix 7 – Growth Zone model

Some materials have been removed from this thesis due to Third Party Copyright. Pages where material has been removed are clearly marked in the electronic version. The unabridged version of the thesis can be viewed at the Lanchester Library, Coventry University.

Appendix 8 – Ladder model

Some materials have been removed from this thesis due to Third Party Copyright. Pages where material has been removed are clearly marked in the electronic version. The unabridged version of the thesis can be viewed at the Lanchester Library, Coventry University.

Appendix 9 – Intervention feedback form

How do you rate the content of the intervention?

1 - Very poor

2 - Poor

3 - Fair

4 - good

5 - Excellent

How do you rate the delivery of the intervention?

1 - Very poor

2 - Poor

3 - Fair

4 - good

5 - Excellent

What, if anything, have you learnt from the intervention about how to approach the maths in your course?

What did you find most helpful about the intervention?

What could be improved about the intervention?

Which methods did you learn about that you will continue to use?

Did the intervention make you more likely to use the services sigma offers?

Yes

No

Why are you not more likely to use the services sigma offers?

Why are you more likely to use sigma's services?

I am more aware of how sigma can help

The intervention helped me overcome some of the anxiety I have around maths and seeking help

Both

Another reason

Appendix 10 - Contributions to published journal articles

Article 1:

Gokhool, F, Lawson, D, Hodds, M, and Aslam, F (2021) Exploring differential engagement with mathematics support from an engineering student focus. Teaching Mathematics and Its Applications Available from: https://doiorg/101093/teamat/hrab033

This paper investigates a subset of the data analysed in Chapter 4 of this thesis. The effect of multiple student characteristics on student engagement with mathematics support is explored: namely, gender, age, disability, ethnicity and engineering course Binary logistic regression analysis is used with all variables included in the model

Article 2:

Gokhool, F, Lawson, D & Hodds, M 2022, 'Investigating the relationship between mathematics anxiety, mathematical resilience and mathematics support engagement: an analysis of demographic and cohort factors', MSOR Connections, vol 20, no 2, pp 82-93 https://doiorg/1021100/msorv20i21321

This paper focuses on analysing a subset of the data analysed in Chapter 5 of this thesis Student demographic characteristics, their course of study, mathematics anxiety, and mathematical resilience are considered in relation to engagement with mathematics support to identify the relationship between the factors An ANCOVA model was used to achieve this

<table>
<tr><td></td><td>First author*</td><td>Second author*</td><td>Third author*</td><td>Fourth author**</td></tr>
<tr><td></td><td>Farhana Gokhool</td><td>Duncan Lawson</td><td>Mark Hodds</td><td>Farzana Aslam</td></tr>
<tr><td>Contributions</td><td>Principal researcher</td><td colspan="3" rowspan="3">Provided advice on:
research design
methodology
discussion of results
all draft manuscripts</td></tr>
<tr><td></td><td>Produced first draft</td></tr>
<tr><td></td><td>Made edits suggested by co-authors to</td></tr>
</table>

	produce further drafts	
	Submitted paper in correct format	
	Made edits suggested by journal editors for final submission	

*Both articles

**Article 1