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Why Didn't the Pre-Arrival Intervention to Combat Maths Anxiety Work?

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There has been a growing demand for advanced quantitative skills in UK workplaces in the last twenty years. In response to this, the foundation programme in this study mandates social science, business and biology students to complete a 30-credit mathematics module in their foundation year. However, these students often arrived with grades 4 and 5 at GCSE, and many struggled with the content and suffered from maths anxiety. To combat this, a pre-arrival mathematics intervention was implemented to target these students. The intervention lasted for approximately four weeks and was delivered weekly using the online platform MyMaths, with support from a foundation programme lecturer. The students' maths anxiety was measured in a pre-test post-test design with the 23-item item Mathematics Anxiety Scale – UK (MAS-UK) instrument. Despite the efforts invested, the outcomes did not show any significant reduction in the students' maths anxiety, although written feedback and a focus group showed the intervention eased their cognitive anxiety responses to maths. This study recognises that maths anxiety may be deeply ingrained from childhood and therefore a longer-term strategy rather than a short intervention may be required to permanently reduce students' anxiety around mathematics. Recommendations for practical strategies for tutors are presented.

Introduction

The growing demand for advanced quantitative skills in UK workplaces has driven universities, including the institution under investigation, to incorporate mathematical content into various courses, especially in social science, business, and physical sciences. In response to this, many university foundation programmes, including the one in this study, have strengthened their curricula by amplifying the mathematics content tailored for non-mathematicians. Students participating in these foundation programmes often come from widening participation backgrounds, which may involve attending disadvantaged schools lacking qualified mathematics teachers, experiencing interrupted education, or facing disabilities and mental health challenges (Laing & Robinson, 2003; Leech & Marshall, 2016).

For many of these students pursuing non-physical science degrees, the inclusion of mathematics in their university course was not anticipated. Previous unsuccessful learning

experiences might have contributed to 'maths anxiety', which may have resulted in them avoiding the pursuit of A-level mathematics (Brown *et al*., 2008; Mathias *et al.,* 2023).

To address this challenge, a study was conducted to examine the potential of implementing a pre-arrival mathematics intervention programme to decrease maths anxiety among students enrolled in foundation programmes. These students are pursuing various degrees and are therefore studying a mathematics module tailored to their disciplines. The programme evaluation sought to determine whether students' maths anxiety reduced subsequent to the pre-arrival maths intervention and whether they exhibited lower maths anxiety scores by the end of the teaching year. By investigating these factors, the study aims to shed light on the effectiveness of the intervention in alleviating maths anxiety and promoting a more positive learning experience for foundation students pursuing degrees with mathematical components.

Maths Anxiety and Intervention

Maths anxiety refers to a feeling of fear, apprehension, or panic that arises when faced with tasks involving mathematics, leading to low performance in mathematical tasks, decreased self-belief, and avoidance (Barroso *et al*., 2021; Ashcraft & Kirk, 2001). It can emerge as early as primary school, persisting into adulthood, and can affect university students in various disciplines across countries and sectors (Khasawneh *et al*., 2021). Students with maths anxiety often avoid studying mathematics where possible but their anxiety resurfaces when they are required to do so (Jameson, 2020).

Maths anxiety encompasses three types of anxiety: test anxiety (anxiety during assessment and evaluation, or doing maths in front of others); social anxiety (anxiety in social mathematics settings or during everyday maths tasks such as adding up change); and observation anxiety (anxiety when watching other doing mathematics, listening to others talk about maths, or seeing maths-related words), with test anxiety having the most significant impact (Hunt *et al*., 2011). Reducing maths anxiety involves two main areas of intervention: improving mathematics skills through exposure in a supportive environment; and addressing the impact of emotions on cognitive abilities such as improving resilience (Johnston-Wilder *et al*., 2021; Petronzi *et al*., 2021; Ramirez *et al*., 2018).

Mathematics skills interventions have the potential to enhance mathematics competency and, consequently, reduce maths anxiety (Foley, 2017; Passolunghi & Pellizzoni, 2020). Studies have demonstrated that improving mathematics skills and increasing exposure to mathematics can effectively reduce maths anxiety and desensitise individuals to the subject (Petersen & Hyde, 2017). However, most of these interventions have been conducted among primary school children, and mathematics interventions for adult learners are relatively rare. This study aims to address two questions:

1. Does the pre-arrival mathematics intervention reduce maths anxiety for foundation students?
2. Does studying mathematics during the foundation year alleviate maths anxiety?

Foundation Pre-Arrival Maths Intervention and Foundation Mathematics

The foundation programme of the university in this study has incorporated mathematics modules tailored to various disciplines, such as Mathematics 1 (M1) for Social Science, Mathematics 2 (M2) for Business and Biological Science, and Mathematics 3 for Computer Science and Economics. Most students, mature or young, in this study come from non-traditional backgrounds, including schools where education was inadequately provided, as shown in Attainment 8 data (Department for Education, 2023), and they have experienced disruptions in their personal learning journey due to family, disability, and mental health challenges. The younger students also encountered disrupted education due to the impact of Covid-19 in the last school years since 2020. It is reported that the pandemic had, on average, a detrimental effect on learning, particularly in mathematics and science subjects (Di Pietro, 2023), which, in turn, would increase maths anxiety (Whyte & Anthony, 2007) due to an even larger knowledge gap. The study specifically focuses on the intervention for maths anxiety among students studying Mathematics 1 (M1) and Mathematics 2 (M2). Many of these students have GCSE mathematics grades of 4 and 5, and they are expected to significantly improve their mathematics skills through an intensive year-long programme.

The pre-arrival mathematics intervention course began in late August 2022 and comprised six sessions over four weeks. All students who are expected to start the foundation course received a welcoming letter and instructions for the course, which included two activities. The first activity involved studying weekly learning material and completing tasks using MyMaths, an interactive online teaching and practice website designed for UK schools (https://www.mymaths.co.uk). The study content covered topics such as numbers, fractions, expanding algebraic expressions, linear equations, simultaneous equations, and more, all at the UK GCSE Foundation level. The objective was to expose the students as much as possible to these topics so they may have lower levels of anxiety while learning throughout the year. Additionally, the students (n = 24) from M1 and M2 who achieved GCSE grades 5 or below were invited to attend online synchronous teaching sessions twice a week for four weeks; however, only thirteen students agreed to join the online course. A former foundation student was also invited to the first session to share their experiences with the foundation course.

Maths Anxiety Survey

A mixed methods approach was used for this study. This consisted of a pre- and post-test experimental design, combined with a focus group. The 23-item Mathematics Anxiety Scale – UK (MAS-UK), developed by Hunt *et al*. (2011), was used to measure students' levels of maths anxiety at three points throughout the academic year. MAS-UK is a commonly used and well-validated instrument based on the longer Maths Anxiety Rating Scale by Richardson and Suinn (1972). Furthermore, MAS-UK has been successfully used with higher education foundation students in the UK in previous research (e.g. Marshall *et al*., 2017; Ryan & Fitzmaurice, 2017). Table 1 shows the schedule of data collection points for the MAS-UK questionnaire and focus group.

Point of the year	**Data collected and number of participants**
September 2022: Before the intervention	**Pre-test** maths anxiety questionnaire n = 7
October 2022: After the intervention	**Post-test 1** maths anxiety questionnaire and additional intervention evaluation questions n = 24
October 2022: After the post-test 1 questionnaire	**Focus group** to discuss students' feelings about maths before and after the intervention n = 2
March 2023: At the end of the teaching year (before exams)	**Post-test 2** maths anxiety questionnaire n = 23

Table 1: Schedule of data collection points

The researcher external to the foundation programme contacted the students for participation in the questionnaires and focus group in order to avoid ethical implications of the tutor requesting this, and also to reduce students' potential concerns about participating. The external researcher also conducted the focus group so that students felt more comfortable discussing their true feelings about the intervention and the tutor running it.

All three questionnaires distributed to students included questions to establish a unique identification code that could be used across the three survey points to match participants to their previous answers while remaining anonymous. Every questionnaire also included a consent form, and students were provided with an information sheet and privacy notice upon invitation. The initial pre-test questionnaire was sent only to students who had agreed to attend the online course and achieved grades 4 or 5 at GCSE level (n = 13), of which 53.8% responded. The subsequent post-test invitations were sent to all students on the foundation programme in M1 and M2 groups (n = 41), of which 24 (59%) responded to post-test 1 and 23 (56%) responded to post-test 2. Twelve paired responses were found between post-test 1 and 2, while only three pairs were found between pre-test and post-test 1.

The maths anxiety data was tested for normality using Shapiro-Wilk tests. Where it was found to be non-normal (between the pre- and post-test 1 points), Wilcoxon signed rank tests were used to compare the levels of maths anxiety over time. Where the data was normal (between the post-test 1 and 2 points), paired-sample t-tests were used. The maths anxiety scores between M1 and M2 were also compared at the post-test 1 point using a Mann-Whitney U test. Each component of maths anxiety (test anxiety, social anxiety, and observation anxiety) was also compared. Normality tests were run for each component, and a t-test was used where the data was normal, with Mann-Whitney U tests used for the non-normal data.

Other quantitative data collected includes intervention participation rates, and a question that directly asked students whether they felt their level of maths anxiety has increased, decreased, or stayed the same over the course of the intervention, and subsequently, the teaching year. This additional quantitative data was analysed using descriptive and inferential statistics. Qualitative data evaluating the intervention was also collected from the questionnaires.

The focus group participants were invited in a separate email, providing them with an additional information sheet, privacy notice, and consent form. This qualitative data was analysed using framework analysis for focus groups (Rabiee, 2004) where themes can develop from both the research questions and participants' narratives. A framework analysis considers not

just the words used, their meanings, and the context, but also how frequently the words and concepts arise and the intensity of the comments around them.

Results and Discussion

Attendance and Engagement in the Pre-Arrival Intervention

Attendance and engagement in the sessions was considered as a factor for judging the success of the intervention. Figure 1 shows the number of tutor-led sessions that the students who were invited to the intervention attended. Eleven students did not attend at all, and five students attended just once. Only two students attended all six sessions. There are several factors that may have contributed to this and to gain some insight into these, the questionnaire included an open-text question asking students why they did not engage in the intervention. Answers included 'prior commitments' such as work or holidays, not realising the intervention was on, and having the intention to participate but not completing the work on time so deciding not to attend the tutor sessions.

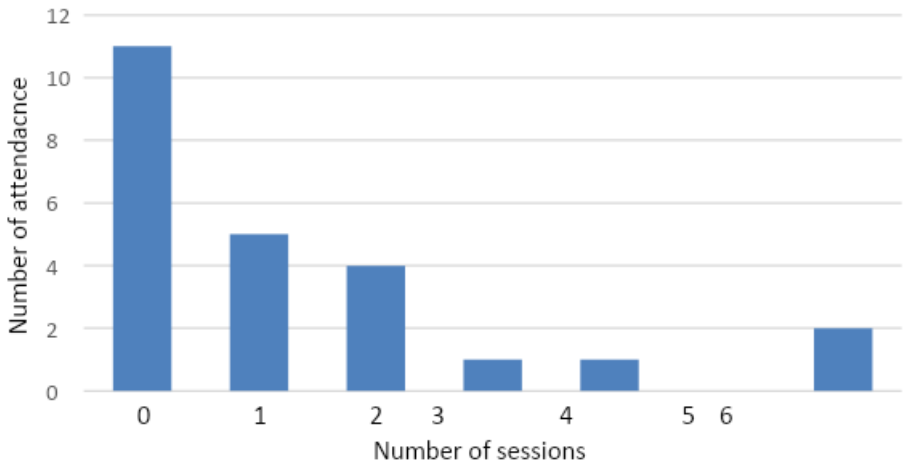

Figure 1: Number of tutor-led sessions invited students attended (n = 24)

Figure 2 displays completion percentages of MyMaths task for M1 and M2 groups. Lower grade GCSE students (grades 4 or 5) completed fewer tasks, suggesting potential content difficulties or lower enthusiasm towards mathematics in their curriculum.

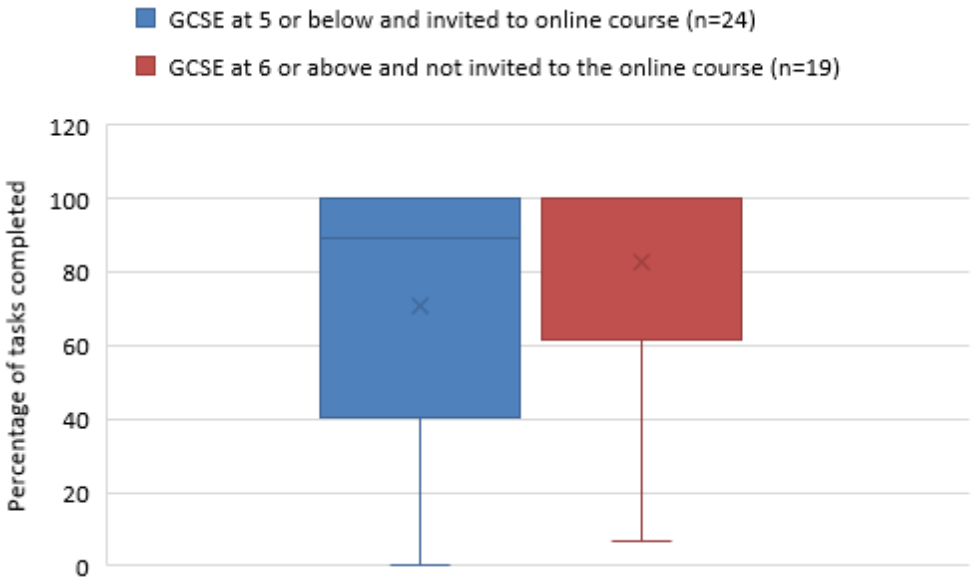

Figure 2: The percentage of tasks completed by groups M1 and M2

Maths Anxiety Before and After the Intervention

The maths anxiety scores between M1 and M2 were compared at the post-test 1 point. There was no significant difference between the two groups ($U = 60.5$, $p = .514$). There was also no significant difference between the two groups for any of the maths anxiety components of test anxiety ($t(23) = -0.10$, $p = .924$), social anxiety ($t(23) = -0.19$, $p = .852$), and observation anxiety ($U = 66.0$, $p = .730$).

When comparing the maths anxiety scores between the students who completed both the pre-test and post-test 1 ($n = 3$), no difference was found ($Z = -1.07$, $p = .285$). This suggests that the intervention had no effect on students' maths anxiety levels. However, the questionnaire also directly inquired about students' feelings of increased or decreased anxiety after the pre-arrival intervention. Figure 3 shows the results of this self-reported anxiety ($n = 24$), revealing that eighteen students reported they felt less anxious, and only one student felt more anxious.

The difference in the direct question about maths anxiety is a contradictory result to the MAS-UK score analysis. There are several potential reasons for this. It is plausible that students' emotional feelings towards mathematics may not have undergone significant change, but students may cognitively believe they should be less anxious because of recent exposure to mathematics. Additionally, due to the fact they have encountered mathematics in a new environment that is not the school setting they were used to, they may feel that the foundation programme is a new start, and there may therefore be an element of wishful thinking on the students' part.

Another possibility is that the MAS-UK scale is not entirely suitable for this particular group of students. Some questions about mathematics, such as 'adding up a pile of change' or 'being given a telephone number and having to remember it', may not directly apply to the experience of these students, either within the foundation course or in their everyday lives, despite the instrument having been used successfully with similar cohorts of foundation students previously.

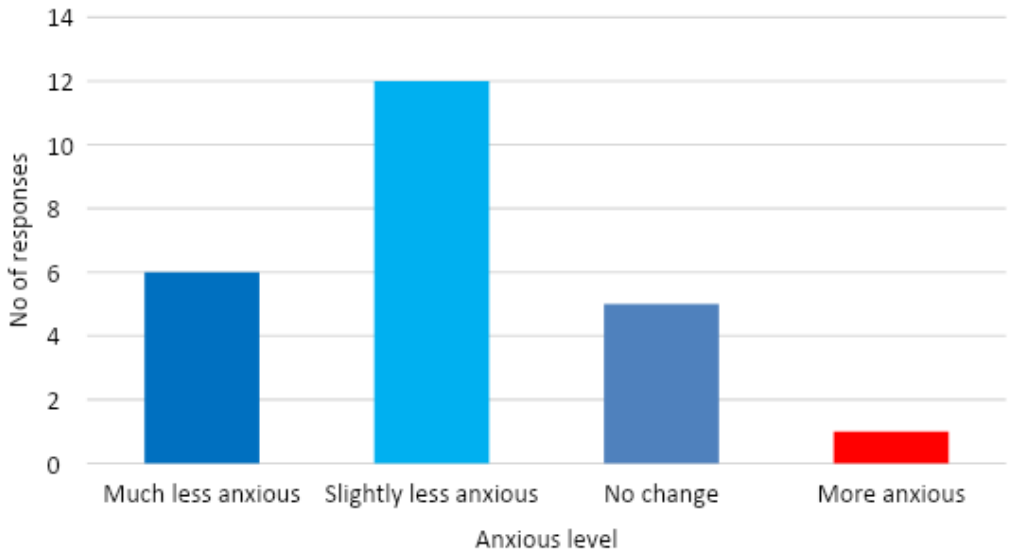

Figure 3: Self-reported anxiety change after the intervention

Focus Group Results

The framework analysis (Rabiee, 2004) generated four main themes which are discussed in turn below.

Bad Past Experiences with Mathematics

Both students expressed a general dislike of mathematics. For both participants (P1 and P2), this was mostly due to negative past experiences, mainly with the teachers. P1 said:

> Maths teachers growing up was not patient, so it's like you always have like that imaginary like image in your head of like a teacher screaming at you 'cause you don't understand.

P1 went on to discuss a time when the teacher had asked them 'Are you daft?' when they had struggled to read a clock in primary school. Both students also mentioned that maths teachers often seem to cover material much faster than other subjects, and they found that challenging, making maths seem difficult and scary:

> P1: And so for like maths lessons, it goes so quickly, don't they.
> P2: I know!
> P1: They go so fast. I feel like in English, they can take their time. And they go through everything and they're like, 'Oh, are youse okay? And then like maths, it's like, 'Da-da-da-da, okay, we're done.'

This is consistent with existing research on maths anxiety (Estonanto & Dio, 2017; Jackson & Leffingwell, 1999) which suggests that teachers who humiliate students, draw attention to their mistakes, show biases, or have otherwise negative attitudes, can increase their students'

anxiety about maths. However, the negative effect of bad past experiences has also been shown to be more due to general and test anxiety (O'Leary *et al*., 2017).

Uncovering the concrete repercussions of the Covid-19 pandemic posed a challenge, given the limited participation in the focus group – only two students took part, and their responses either omitted or overlooked specific details regarding the impacts of Covid. Nevertheless, as previously noted, reviews of the pandemic's impact on the learning progress of school-aged children indicated an overall adverse effect. Notably, learning deficits are particularly pronounced among children from low socio-economic backgrounds, especially in the realm of mathematics (Betthäuser *et al*., 2023).

Knowing the Basics Enhances Confidence

The students felt that the intervention taught them the more basic stuff that people 'should already know' (P1) and this helped them to 'get back into maths' (P2), particularly as they hadn't done mathematics for a long time. There therefore helped the students with comfort and confidence, and reduce their fear:

> When I was envisioning like [university] maths, I was like, 'quantum physics' […] then [the tutor] was like, 'Oh we're gonna start slow.' I was like, 'Oh.' (P1)

This is consistent with the literature, where missing basics and knowledge gaps can cause maths anxiety for students and make further learning more difficult (Whyte & Anthony, 2007). The comfort and confidence from the intervention does not just occur with the mathematics itself, but the students also felt that it helped them to become familiar and reduce their nervousness of the technological tools being used:

> P1: When we went to maths lessons, some people actually struggled to get on MyMaths, and we were already – we were already there.
> P2: Yeah.

A Supportive Tutor is Important

The students expressed multiple times that having a patient and compassionate tutor was a major part of why they did not experience higher levels of anxiety in the intervention maths sessions:

> P1: She was really patient. And she did go slow. […] And she like, purposely like if someone was confused, you could just ask about it. And it was, I feel like an actual like lesson, you get so embarrassed.
> P2: [laugh]
> P1: Like, asking for stuff. But in this one, I didn't feel that bad. […]
> P2: Compared to my last teacher, she was very – uh yeah she was very patient, slow. Even if people didn't say, 'Oh I'm stuck', she'd pause and then ask each of us.

This extract shows that having a tutor who is compassionate when students ask questions is important. This can help break the cycle of maths anxiety caused by poor tutors from the past, and is something that has been found in other maths anxiety research (Marshall *et al*., 2017).

Desire to Work with Other People

Although the students in this focus group had positive tutor experiences, they expressed a desire for more group work, particularly if the tutor was not present. They discussed the idea of breakout rooms which would allow them to learn from each other:

> You'd probably be like, 'I know how to do the first step but I don't know how to do the second step', and somebody would be like, 'Oh well actually, I know how to do the second step but I don't know how to do this third step.' (P1)

They also expressed that a groupwork environment without the tutor would help them to be honest if they were struggling with a particular concept, which they would be reluctant to do in front of the tutor. This was mainly for fear of being embarrassed, even though they also said they felt comfortable with the tutor.

Academic Year's Impact on Maths Anxiety

A comparative analysis of mathematics anxiety scores was conducted between the beginning of the academic year in October 2022 and its completion in March 2023. A paired t-test, based on a sample size of n = 12, revealed no statistically significant changes in test anxiety ($t(11) = -0.397$, $p = 0.349$), social anxiety ($t(11) = -0.852$, $p = 0.412$), and observational anxiety ($t(11) = -0.411$, $p = 0.689$). The non-significant findings may be attributed to the limited size of the dataset. However, noteworthy insights emerged from both qualitative and descriptive evaluations. An apparent increase in test anxiety was reported by students, while social anxiety was reduced and observational anxiety remained unchanged, as depicted in Figure 4. Tutors also observed a significant rise in anxiety levels among a few students, corroborated by the results shown in Figure 4.

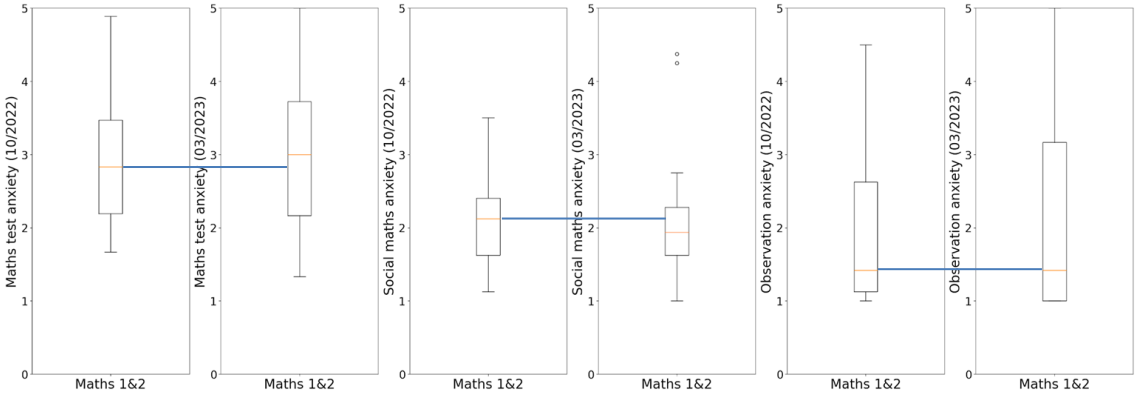

Figure 4: Comparison of maths anxiety levels between the start and end of academic year (1 = not anxious, 5 = very anxious)

It is important to note that no strategies specifically aimed at reducing mathematics anxiety were implemented during the academic year, except for the provision of additional maths support to students displaying signs of academic struggle. Given the nature of the foundation programme catering to non-traditional students, many of whom may have come with mental health issues or disabilities, studying mathematics without adequate strategies for combating maths anxiety might have resulted in an increase in their anxiety for a few students.

This observation is supported by the responses from the students, where approximately one third of them reported feeling more anxious about mathematics compared to the start of the year, as shown in Figure 5. It is worth noting that this questionnaire was conducted shortly before exams commenced. Therefore, the students may have been feeling a considerable amount of anxiety and stress regarding their forthcoming mathematics exams, knowing that they must pass all the modules of the programme, including mathematics, to progress. Nevertheless, considering these outcomes, there is a need for further investigation to explore the impact of interventions addressing maths anxiety within the context of the foundation programme.

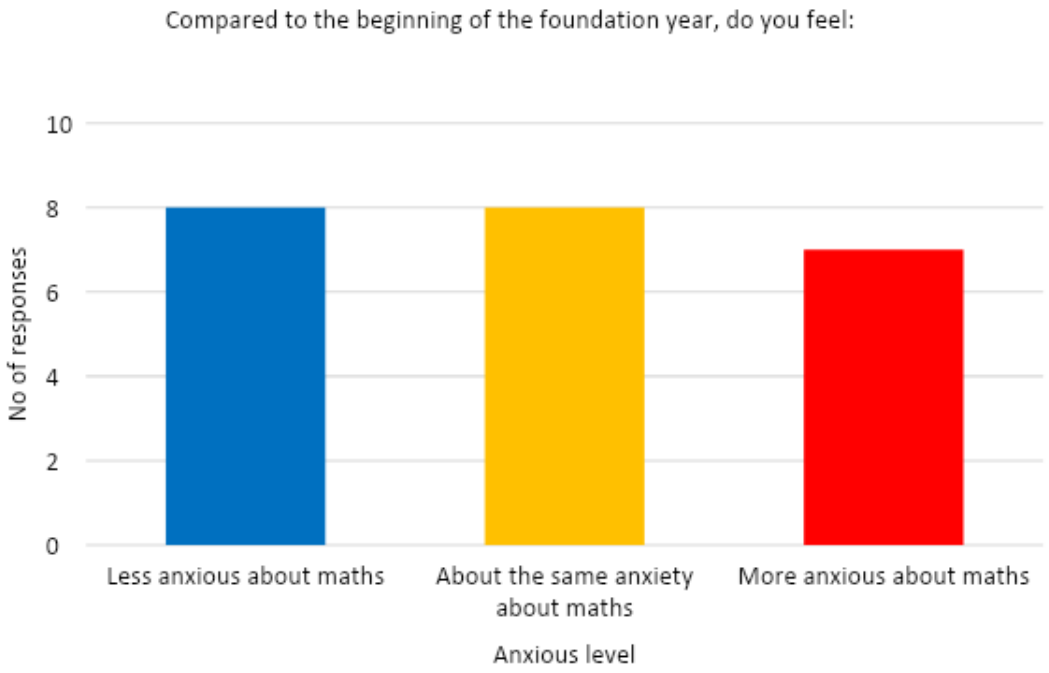

Figure 5: Maths anxiety across the academic year (n = 23)

Conclusion and Recommendations

Maths anxiety is widespread and prevalent. Since it can develop as early as primary school years, it may be deeply ingrained in individuals as they transition into adulthood (Hunt & Maloney, 2022). According to a study carried out by the Organisation for Economic Co-operation and Development, a significant 59% of school children frequently express concerns about learning mathematics (OECD, 2016). Similarly, in a separate study that included over 1000 undergraduate students, a substantial number of participants reported experiencing varying degrees of maths anxiety, ranging from a 'fair amount' to 'much' (Hunt & Sheffield, 2011).

Although maths anxiety is distinct from general anxiety, it can negatively impact students' overall mental health and wellbeing (Demedts *et al*., 2022; Young *et al*., 2012). For foundation students, the presence of mental health issues can cause disengagement and other issues (Storrie *et al*., 2010), potentially compounding maths anxiety, making it even more challenging for affected individuals to engage effectively with mathematical concepts and tasks. This is evidenced in this study by the finding that a considerable proportion of students may become more anxious after studying mathematics in foundation year if these factors are not addressed.

Despite the pre-arrival intervention programme potentially leading students to cognitively believe that they were less anxious about mathematics and viewing the foundation year as a new beginning, maths anxiety may resurface as they encounter more challenging topics (Chan & Tang, 2020). To address maths anxiety effectively, a comprehensive intervention approach is necessary. This should encompass not only supporting students in improving their maths competence and skills but also providing emotional and cognitive interventions to address the underlying psychological factors contributing to their anxiety. It has been shown that making students aware of their own emotional, cognitive, and physical responses to maths anxiety may reduce its impact; for example, by cognitive restructuring, or using a workshop at the start of a course (Marshall *et al*., 2017; Ramirez *et al*., 2018). Reducing the amount of worrying students experienced about their levels of anxiety can help to liberate working memory that can then be used for engagement in mathematics tasks (Ashcraft & Krause, 2007). Supportive tutors and environments have also been effective in enhancing students' relationships with mathematics (Marshall *et al*., 2017).

Given the complexity and persistence of maths anxiety in foundation students, a longer-term strategy is crucial for sustained improvement. Although intensive cognitive tutoring has been shown to work with children (Supekar *et al*., 2015), short-term solutions may not yield lasting results for adults with more ingrained maths anxiety, and a more extended, continuous effort may be required to help students overcome their anxiety and develop a positive relationship with mathematics.

For foundation students, several practical strategies could be implemented. Examples of strategies could include:

(1) Identifying students with maths anxiety as early as possible by closely monitoring those who exhibit low performance or signs of distress in mathematical tasks, or by carrying out diagnostic maths anxiety surveys.

(2) Creating a supportive and non-judgemental environment that fosters open communication, allowing students to feel comfortable expressing their feelings and concerns about mathematics.

(3) Showing patience and compassion to students, supporting them to ask questions and for help.

(4) Encouraging students to utilise safe and confidential platforms, such as a mental health support group or an anonymous reporting system, where they can voluntarily seek help or share their concerns.

(5) Educating students about the cognitive and emotional effects of maths anxiety on their learning and performance, helping them gain awareness and understanding of this common issue.

(6) Teaching resilience-building techniques and positive self-talk to empower students to reframe negative thoughts and cultivate a growth mindset towards mathematics.

By implementing these practical strategies, educational institutions can better support foundation students in overcoming maths anxiety, fostering a positive learning experience, and promoting emotional well-being.

Now more than ever, university students must embrace mathematics in their respective fields to meet the growing demand for quantitative skills in the workforce. However, maths

anxiety issues could pose a significant barrier for them. Moreover, transition from a foundation year to degree level often requires successful completion of all modules, including mathematics. For these students, their academic futures may become intertwined with a subject-induced anxiety, leading to a reluctance to study. This is especially true for foundation students in non-mathematical disciplines, as these concerns could impede their progress towards their degree, resulting in the loss of an opportunity to access higher education, despite their evident talent and passion for their chosen field. This paper emphasises the crucial significance of implementing a long-term and persistent strategy to support these students with maths anxiety in succeeding throughout their foundation program and beyond. By providing comprehensive and sustained support, we can help them overcome maths anxiety and pave the way for their academic and professional success.

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