Final report

A survey of Mathematics Anxiety and Mathematical Resilience among existing apprentices

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Contents

Foreword

In undertaking this survey, we have been mindful of the importance of apprenticeships to the UK, especially England, and the problem of recruiting more STEM apprentices. The report explores the extent to which mathematics anxiety underpins the concerns of apprentices in the UK regarding recruitment and progression.

The problem of mathematics anxiety pervades Western nations. An Australian researcher writes:

'Unfortunately, and perhaps because avoidance is the ultimate consequence of mathematics anxiety, the numbers of students enrolling in advanced subjects and in any mathematics subject in upper secondary school are declining, with girls in particular choosing not to pursue mathematics into their senior years. The Chief Scientist commented that in order to address this downward trend, 'the understanding of the pervasiveness in and importance of mathematics, engineering and science to Australia's future needs to be promoted and nurtured across the community."' (Buckley 2013)

Across UK political parties there appears to be an awareness of the mathematics problem, but far less consensus on how to best tackle it. There is perhaps also less awareness of the role played by mathematics anxiety which is shown here to be an important consideration in making strategic decisions.

The presence and extent of mathematics anxiety as a significant phenomenon amongst Apprentices is demonstrated in this report. Therefore, it is likely that mathematics anxiety will have an effect on potential recruits before choices are made and could potentially affect those choices.

Clearly the uptake of Apprenticeship provision in STEM related sectors will be affected by the potential applicants' previous experience of mathematics. Thus, in this study, the extent of mathematics anxiety as a factor in decision-making is of equal concern with respect to STEM sector apprenticeships as it is to nonSTEM sector apprenticeships. In other words, the presence of mathematics anxiety is potentially significant in both populations (STEM and nonSTEM), since its presence could influence potential applicants in their choice of sector.

The Coaching for Mathematical Resilience Group has established, in this report, that mathematics anxiety is present within both STEM related and nonSTEM related Apprenticeship settings. It is timely, therefore, to design improved mathematics teaching and learning, within both STEM-related sectors and in nonSTEM apprenticeship sectors but also in **Pre-Apprenticeship** education and training to address the supply and progression of Apprentices for the 21st Century.

Based on the developmental work of the Coaching for Mathematical Resilience Group, the UK now has an opportunity to address the supply and progression of STEM apprentices more effectively.

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." (Lyons and Beilock, 2013)

Executive summary

This research develops knowledge of the extent to which apprentices in the UK are affected by mathematics anxiety, including issues related to prior mathematics achievement, gender, and choice of apprenticeship, as well as outlining significant implications for both the supply and progression of STEM Apprentices.

To what degree is mathematics anxiety an issue for Apprentices?

- Mathematics anxiety has a noticeable impact on about 30% of the respondents. Another 19% have a tendency to be anxious but may not show such clear signs.
- The degree of mathematics anxiety in apprentices is roughly equal to that in the rest of the population. Here it is known to both negatively impact on daily life (e.g., calculating a tip at a restaurant) and on formal education, *"ultimately resulting in lower exposure to math, reduced practice using mathematics principles, and reduced workforce math competence".* (Brunye, 2013)
- The high prevalence of mathematics anxiety in the overall apprentice population has a confounding influence on some statistically significant differences in mathematical anxiety associated with three key characteristics: prior mathematics achievement; gender; and STEM and nonSTEM apprenticeship study.

In respect of these key characteristics our findings highlight that:

  - Mathematics anxiety is more prevalent among apprentices who have not yet gained Grade 2 mathematics.
  - Mathematics anxiety is more prevalent among female apprentices than male apprentices.
  - Females are more likely to be found on non-STEM apprenticeships than on STEM apprenticeships.
  - Mathematics anxiety is more prevalent among non-STEM apprentices than STEM apprentices.
  - One sixth of STEM apprentices experience their mind going blank when faced with mathematics.

In this report, we argue that mathematics anxiety is affecting both recruitment and progress of STEM apprentices.

What are the implications for the supply of STEM Apprentices?

- Addressing mathematics anxiety in the pre- or early- apprentice population may be significant in increasing the pool of potential STEM apprentices in two ways:
  - Making progression *possible*: Increasing the number of pupils reaching higher levels of mathematics attainment, so increasing their potential for apprenticeship study, (particularly STEM apprenticeships) requiring higher levels of mathematics skill.
  - Making progression more *probable*: Increasing the number of pupils for whom mathematics anxiety is not a barrier when considering STEM apprenticeships as their next step.

What are the implications for the success of STEM Apprentices?

- For some apprentices, mathematics within this framework is significantly different from school mathematics. Mathematics anxiety is a significant problem on apprenticeships, STEM or nonSTEM, with harder mathematics than expected.
- Previous research establishes that mathematics anxiety is highly likely to be hindering well-being and progress (for example, Brunye 2013). It is also established that purpose and utility makes mathematics more accessible to people who have previously been excluded from mathematics, and more so for females.
- For many people, the problem "is only in maths". We suggest that addressing mathematics anxiety could be significant to overall apprenticeship success and well-being and have positive impacts on both recruitment and progress for many apprentices.

1 Introduction

1.1 Context

For over 40 years, mathematics anxiety has been recognised as “feelings of tension and anxiety that interfere with the manipulation of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson and Suinn, 1972, p.551). It is established that mathematics anxiety has a negative influence on working memory (Ashcraft et al, 1998) and Skemp (1971) suggested that reflective activity is inhibited by mathematics anxiety. Studies from many countries have shown that performance in mathematics is negatively correlated to mathematics anxiety (see for example: Betz, 1978; Hembree, 1990; Ma, 1999; Dowker, 2005; Ashcraft and Krause, 2007; Brunyé et al, 2013).

Ashcraft and Krause (2007) note that mathematics anxiety leads to an avoidance pattern; whenever possible, students avoid taking mathematics classes and avoid situations in which mathematics may be necessary. Many students described as unmotivated (in mathematics) are in actuality highly motivated - not to learn, but to avoid failure (Covington 1992). According to Dweck (2000), failure can motivate or undermine, depending on whether students’ reactions are mastery-oriented or helpless. Too many children and adults give up on mathematics learning by withdrawing effort from any task that is perceived as likely to result in failure (Chinn, 2012).

Recent government policy has begun to recognise the importance of the affective domain in learning mathematics. For example, Education Minister Elizabeth Truss (March, 2014) acknowledged the need for ‘confidence’. The Welsh government has asked parents to be careful what they say about mathematics, to help foster a more positive attitude.

The recent Pisa (2012) study shows England has a long tail of underachieving students in mathematics. The gap between high and low achievers appears to be widening. Students in England have low levels of perseverance in mathematics. Bandura says learners need ‘resilient self-efficacy’ to manage the affective domain when students meet unknowns and failure. Elsewhere, consultation documents are more explicit about evidence of the need to manage stress by reaching out to others and by being given choice and control (National Voice, 2014).

It is clear (SFR13/2013) that at least 85% of the UK population as a whole are capable of attaining qualifications to Level 2+. However, the proportion of young people aged 19 in 2012 that attained Level 2 with English and mathematics in 2012 was 62%. Thus, the overall estimate of the population that is underachieving at this level in mathematics and English is 23%. Two-thirds of students who achieved a D grade in mathematics GCSE at secondary school (54,000 young people) did not enter the exam in post-16 education. This is indicative of the large supply pool of potential apprentices who could achieve grade C in mathematics within a year, a pool that would be accessible if learners can be switched into a growth/progression mindset in mathematics. This switch could, furthermore, offer a more robust supply of nonSTEM apprentices. If, as we suspect, these young people are affected by mathematics anxiety or avoidance, then addressing the issue of mathematics anxiety would also increase the supply of STEM apprentices.

Before we undertook this project, the proportion of current apprentices affected by mathematics anxiety or avoidance was unknown. Therefore, it was not possible to predict to what extent this specific sub-group of the UK population would benefit from a Coaching for Mathematical Resilience (CfMR) programme. This project sought to address these gaps in knowledge by answering the following research questions:

- **Research question 1 (RQ1):** to what extent are STEM and nonSTEM apprentices affected by mathematics anxiety?
- **Research question 2 (RQ2):** to what extent does mathematics anxiety affect choice of apprenticeship?
- **Research question 3 (RQ3):** to what extent are STEM and nonSTEM apprentices mathematically resilient?

If, as we predicted, mathematics anxiety is a key factor amongst apprentices, there is an intervention available at group level that has previously led directly to decreasing mathematical anxiety – the Coaching for Mathematical Resilience (CfMR) programme.

1.2 Research Team

The CfMR Group comprises a partnership of three organisations that bring key complementary elements to bear on the challenge of mathematics anxiety: The University of Warwick, The Progression Trust (TPT), and the national educational charity organisation ASDAN.

Sue Johnston-Wilder and Clare Lee coined the term ‘mathematical resilience’ as a potential antidote for mathematics anxiety and mathematics helplessness; they developed the four-part construct upon which subsequent work has built internationally. Johnston-Wilder and Lee continue to lead research and development relating to the construct. The CfMR group has established proof of concept that it is possible to transform training adults from ‘can’t do’ mathematical avoidance, or mathematics anxiety, to ‘can do’ mathematical resilience. As predicted by theory, this enables apprentice trainers to overcome personal mathematics anxiety and to support learners in developing their own ‘can-do’ attitude. (See Johnston-Wilder et al, 2013.)

The broad and deep expertise within the Centre for Education Studies and across the university means that world-class research can be undertaken flexibly. In particular, the Centre for Education and Industry (CEI) offered an experienced, university-wide service in the collection of online data.

The Progression Trust (TPT) specialises in the translation into practice of theory and research relating to progression across the life-course. This partnership has meant a significant contribution to understanding the application of the construct mathematical resilience to the work-based learning setting through the development of a coaching model and a programme tailored specifically to the context of addressing mathematics anxiety in an apprenticeship context. The Progression Trust team also bring a long history of development and leadership in every education phase and context including, schools (both Primary and Secondary), colleges, work-based learning providers, universities, local authorities and multi-agency partnerships. TPT managed the relationship with the training providers and contributed to the final report and strategic planning.

For thirty years, ASDAN has been a champion of alternative approaches to curriculum and learning, and brings considerable expertise in pedagogy and assessment that enables the development of wider skills needs, beyond and including core curriculum qualifications. The ASDAN Mathematics Short Course and functional skills materials provide a curriculum and resources fully commensurate with the principles of both the construct of mathematical resilience and the coaching approach, through challenge-based learning, formative assessment, and the 'plan-do-review' learner reflection process. The ASDAN Mathematics Short Course has recently been re-developed and updated jointly with a team from Mathematics in Education and Industry (MEI). ASDAN leads a well-established network of over 5,000 centres nationally, which provide access to partners in the full range of learning contexts. ASDAN supported the relationship with the training providers and contributed to the final report and strategic planning.

2 Methodology

2.1 Overview of methodology

A multi-part questionnaire was issued: the first part asked five contextual questions about the apprentice, such as their highest previous mathematics qualification and the level of apprenticeship they were taking; the second part asked questions about feelings and beliefs about mathematics, incorporating the Betz (1978) Mathematics Anxiety Scale (MAS) to measure the incidence of mathematics anxiety amongst the sample and the Mathematical Resilience Scale (Kooken et al, 2013) to address RQs 1 and 3. The third part asked questions relating to choice of apprenticeship to address RQ2. The final part asked about forthcoming qualifications and plans. The questions were multi-choice, and sometimes offered an additional space for additional comment where applicable. See Appendix A for a copy of the questions.

As a measure of mathematics anxiety, the 98-item Mathematics Anxiety Rating Scale (MARS) has been a major scale used for research and clinical studies since 1972 (Richardson and Suinn, 1972). However, the scale is extremely time-consuming and a variety of other scales are also used in intervention studies. Mahmood and Khatoon (2011) have shown that the various scales measure the same construct without loss of validity and reliability.

In this study, we used the shorter 10-item Mathematics Anxiety Scale (MAS; Betz, 1978), which was deemed more suitable to UK apprentices. MAS has been found to have acceptable internal consistency and test-retest reliability (Dew, Galassi & Galassi, 1984; Pajares & Urdan, 1996)

MAS is a 10-item scale with five items positively worded and five items negatively worded. The questions require self assessment of respondents' experiences of and feelings about studying mathematics, both in class and on tests, using statements such as 'I have usually been at ease in mathematics courses, and 'Mathematics makes me feel uncomfortable and nervous'. Responses are given on a 5-point Likert-type scale with responses ranging from 1 (strongly agree), through 3 (undecided), to 5 (disagree strongly). Half the scores are reversed in order that a high score indicates high mathematics anxiety. Participants were expected to vary widely in mathematics anxiety levels.

The Mathematical Resilience Scale (MRS) is a 23-item scale developed from the construct 'mathematical resilience' (Johnston-Wilder and Lee, 2008, Lee and Johnston-Wilder, 2010, 2014) by Janice Kooken, a US PhD student, working with her supervisors in US and with Johnston-Wilder and Lee in UK (Kooken et al 2013). The MRS has three subscales: Value, Struggle and Growth.

'Value' is based on expectancy-value theory, that students will be more interested and more motivated to study mathematics if they believe it is valuable (Chouinard, Karsenti & Roy, 2007). In MRS, value is characterised by statements such as 'Knowing maths contributes greatly to achieving my goals.'**;** **'**Maths develops good thinking skills that are necessary to succeed in any career.'**;** 'Thinking mathematically can help me with things that matter to me.'

‘Struggle’ is rooted in Bandura’s (1989) theory of personal agency as “the capacity to exercise control over one’s own thought processes, motivation, and action” (p. 175). Human agency is also exercised through collective experiences and culture of a group. In MRS, Struggle is characterised by statements such as: ‘Everyone makes mistakes at times when doing math.’ ‘Struggle is a normal part of working on math.’ ‘Making mistakes is necessary to get good at math.’

‘Growth’ is rooted in the work of Dweck (2000), who found that students with a ‘growth’ mindset seek challenges and develop strategies in response to setbacks. In contrast, students who have a ‘fixed’ mindset tend to avoid activities that result in difficulties, and hence achieve less. In MRS, Growth is characterised by statements such as: ‘Maths can be learned by anyone’ and negatively scored statements such as ‘If someone is not a maths person, they won’t be able to learn much maths’.

Responses are given on a 5-point Likert-type scale with responses ranging from 1 (strongly agree), through 3 (undecided), to 5 (disagree strongly).

2.2 Data collection

The online data was collected using Snap Surveys. The paper-based data was entered into SPSS manually. The data was largely analysed within SPSS utilising the frequency, graphs and charts function to explore data descriptively and the ANOVA functions to test the differences between different sub-groups. R was used for the regression modelling. Scoring of negatively worded items was reversed so that a higher score would indicate higher mathematics anxiety. The BetzScore was calculated by summing the item scores. Then the BetzScores were used to assess the level of mathematics anxiety in each group and sub-group. It was thereby possible to compare the findings with those of other studies reported in the research literature from cohorts around the world, both at the level of individual questions and of group means.

The data collected were then examined to see whether mathematics anxiety levels in our sample on the Betz scale are associated with STEM/nonSTEM, gender, highest mathematics qualification and other variables. Subsequently we tested whether mathematics anxiety levels in our sample on the Betz scale were related to respondents’ decision to choose STEM/nonSTEM apprenticeships.

2.3 Participation

The participation rate for the study was initially much lower than expected due both to reduced availability of the training providers, and to online connectivity issues within the training centers. This was rectified by initiating a second phase of data collection using a paper survey which participants could access more readily. This process (combining responses from online and paper-based questionnaires) led to a total N = 226 participants. This sample size was deemed large enough to yield significant trends that could reliably form the basis of our conclusions.

Data was drawn from local training providers in the Coventry and Warwickshire area; the 226 participants are represented by 20 training providers. In Coventry and Warwickshire there are around 5 times as many nonSTEM apprentices as STEM apprentices. We used a disproportion sampling method to take into account the different sized populations of

STEM and nonSTEM apprentices. We set out to gain sample sizes of 150, looking for a 99% confidence interval of an estimate to the nearest 10%. We gained 83 STEM respondents and 143 nonSTEM respondents. The actual *pq* values were lower than the maximum, as expected. Thus overall, as a rough guide to the reader, the 99% confidence interval of our results is ±11% for STEM and ±10% for nonSTEM.

3 Results

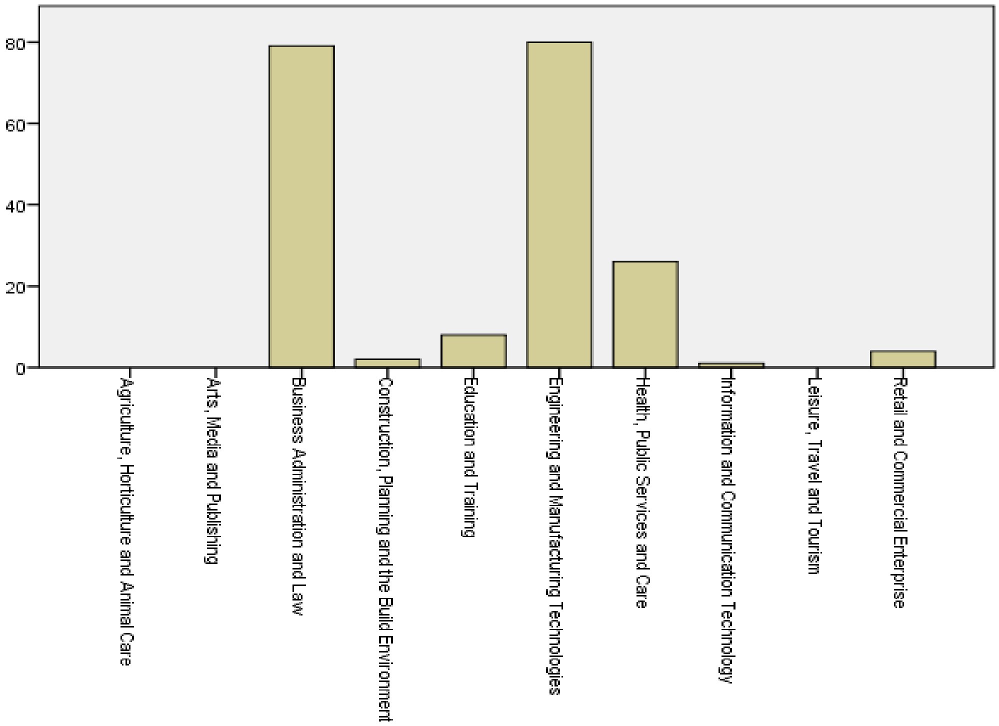
3.1 Contextual data

3.1.1 Which type of apprenticeship you are taking?

The sample is largely drawn from three apprenticeship groups (Figure 1):

- Engineering and manufacturing technologies (STEM);
- Business administration and law (nonSTEM); and
- Health, public service and care (nonSTEM).

Figure 1: Count of respondents by type of apprenticeship



3.1.2 Level of Apprenticeship

We had responses from apprentices at three different levels (Table 1). However, the number of responses from the higher level is relatively small, which means that any inferences made about this group must be interpreted with care.

Table 1: Respondents by level of apprenticeship and Subject type (STEM v Non-STEM)

Level of Apprenticeship	nonSTEM	STEM	Total	% of Total
Intermediate (level 2)	72	27	99	44
Advanced (level 3)	54	56	110	49
Higher (degree equivalent)	17	0	17	7
Total	**143**	**83**	**226**	**100**

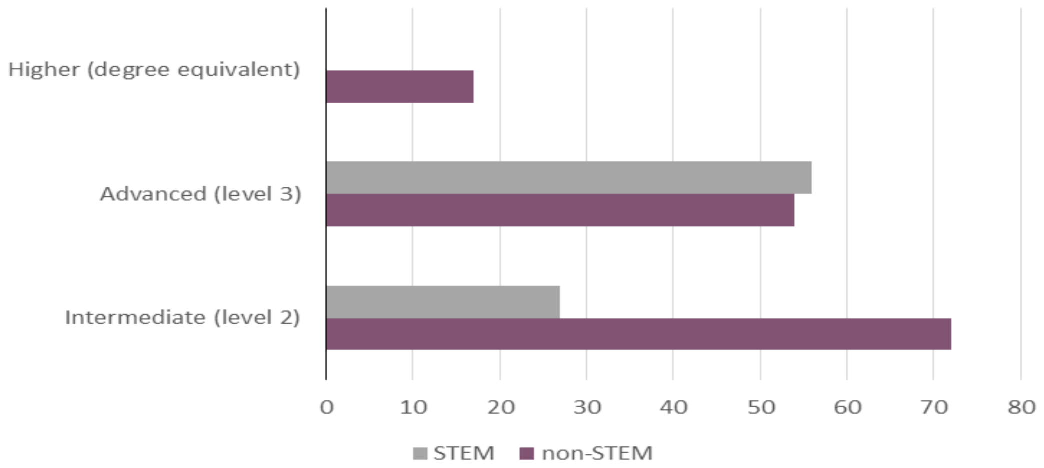


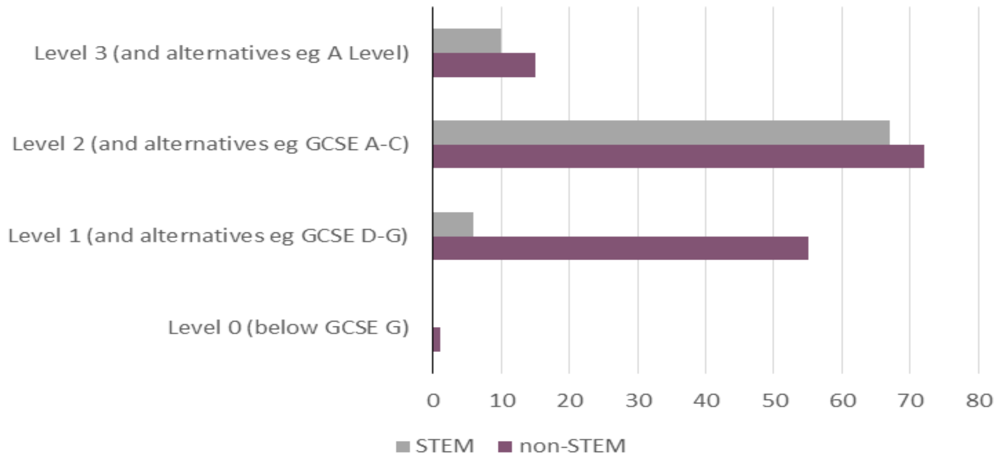
Table 1 demonstrates that non-STEM apprentices are much more likely to be working on Level 2 than STEM apprentices.

3.1.3 Highest mathematics qualification before starting this apprenticeship

The majority of respondents (73%) had already gained at least Level 2 in mathematics (Table 2). However a significant number (27%) were still working towards Level 2. In comparison, in 2012, 6.4% of the national population gained level 2 mathematics, starting from level 1 (SFR13/2013). Table 2 demonstrates that that people whose highest maths qualification is Level 1 and below are much less likely to undertake a STEM apprenticeship.

Table 2: Respondents by highest mathematics qualification (STEM v nonSTEM)

Highest mathematics qualification	nonSTEM	STEM	Total	% of Total
Level 0 (below GCSE G)	1	0	1	0
Level 1 (and alternatives e.g. GCSE D-G)	55	6	61	27
Level 2 (and alternatives e.g. GCSE A-C)	72	67	139	62
Level 3 (and alternatives e.g. A Level)	15	10	25	11
Total	**143**	**83**	**226**	**100**

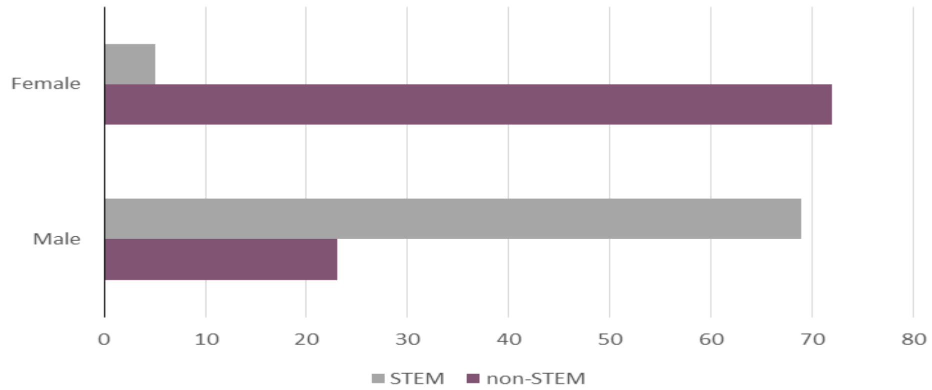


3.1.4 Gender

The sample contains a reasonable balance of both males (41% and females 41%); however 57 participants were missing data (Table 3).

Table 3: Respondents by gender and subject group (STEM v nonSTEM)

Gender	nonSTEM	STEM	Total	% of Total
Male	23	69	92	54
Female	72	5	77	46
Total	**95**	**74**	**169**	**100**

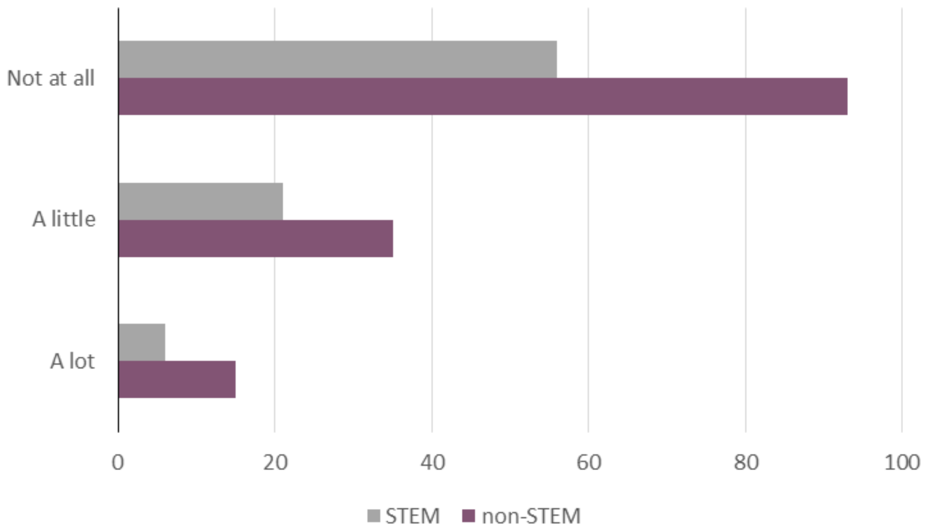


3.1.5 Did your feelings about mathematics affect your choice of apprenticeship?

In responding to this question, 34% of respondents were consciously aware that their feelings about mathematics had influenced their decision (Table 4).

Table 4: Respondents by whether feelings affected choice of apprenticeship (STEM v nonSTEM)

	non-STEM	STEM	Total	% of Total
A lot	15	6	21	9
A little	35	21	56	25
Not at all	93	56	149	66
Total	**143**	**83**	**226**	**100**



The proportion of STEM apprentices who agreed that they had been influenced in their choice by their feelings about maths (32%) is approximately the same as the proportion of non-STEM apprentices (35%).

3.1.6 Additional open comments about choice of apprenticeship

The range of comments suggests there are also other factors, besides mathematics anxiety, influencing the choice of apprenticeship and in some cases helping overcome aversion to mathematics. For example, a strong motivation to complete a given apprenticeship or be accepted for a particular job may help mitigate mathematics anxiety.

Some relevant comments from STEM apprentices

- My drive to do what I wanted, over ruled the feeling I had towards maths
- I am ok with maths and confident in my ability to learn more so I didn't give it a thought [sic]
- I didn't realise how important maths was in my field of work.
- I was a little worried about the maths however not enough to turn the job down
- As I never chose to take Mathematics at A Level I could not go onto take a Higher Apprenticeship, the reason I never chose A Level Mathematics was due to my teacher at GCSE was useless and I had enough of Maths

From nonSTEM apprentices

- They affected me in a lot of ways but have never given up trying
- I am comfortable with maths.
- I wanted to do higher paper but wasn't given the chance - got 178/200
- no because you do not necessarily need maths for business admin

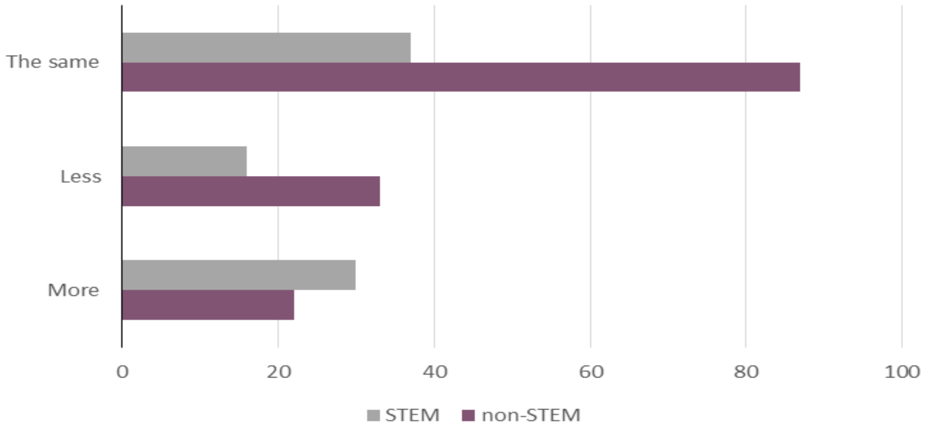
These comments indicate that it is as much about perceived lack of quality mathematics teachers and awareness of the importance of mathematics as feelings about mathematics per se.

3.1.7 Think about when you chose your apprenticeship. Is the amount of mathematics you use now in your apprenticeship more / less or the same as you expected?

Just over half the respondents (55%) reported that they find the amount of mathematics they use in their apprenticeship to be in line with what they expected (Table 5). Of those who said there was more mathematics than expected in the apprenticeship, the majority were STEM apprentices (Table 5).

Table 5: Respondents by whether the amount of mathematics is as expected (STEM v nonSTEM)

	non-STEM	STEM	Total	% of Total
More	22	30	52	23
Less	33	16	49	22
The same	87	37	124	55
Total	**142**	**83**	**225**	**100**



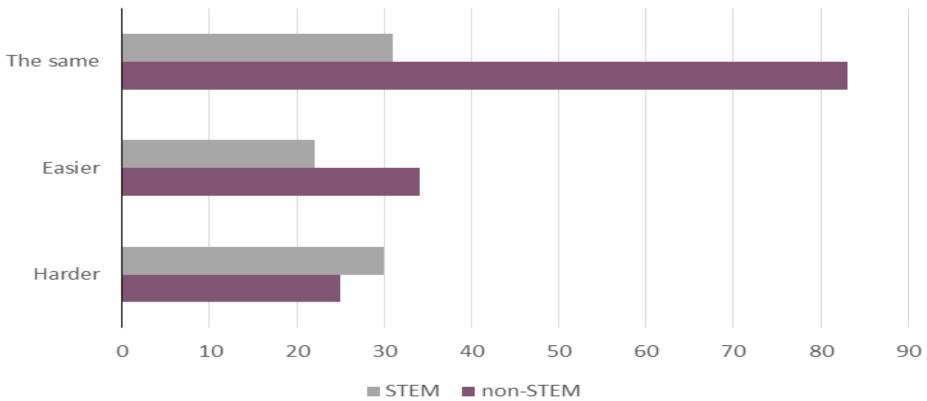
However, STEM apprentices were significantly (p<.001) more likely (36%) to report that the amount of mathematics was more than they expected than were non-STEM apprentices (16%).

3.1.8 Think about when you chose your apprenticeship. Is the difficulty of mathematics you use now in your apprenticeship harder/ easier or the same as you expected?

About half the respondents (51%) report that they find the difficulty of the mathematics they are using in their apprenticeship to be in line with what they expected (Table 6). A larger proportion of nonSTEM apprentices were in this group than STEM apprentices (Table 6). Over a third of STEM apprentices found the mathematics harder than they were expecting. The proportion of STEM apprentices reporting that the mathematics in their apprenticeship was harder than they expected (36%) is significantly higher (p<.001) than the proportion of non-STEM apprentices (18%).

Table 6: Respondents by whether the difficulty of mathematics is as expected (STEM v nonSTEM)

	Non-STEM	STEM	Total	% of Total
Harder	25	30	55	24
Easier	34	22	56	25
The same	83	31	114	51
Total	**142**	**83**	**225**	**100**



Some relevant comments

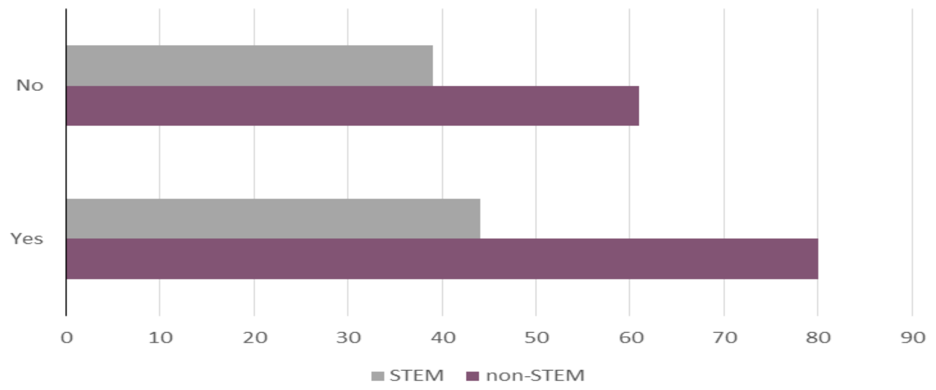
- It's a bigger gap between GCSE and this than I thought

3.1.9 Is the mathematics you do on your apprenticeship different from the mathematics that you did in school?

Table 7 highlights that over half of the respondents said yes to this question (55%). The difference between the proportions of STEM and non-STEM apprentices reporting 'Yes' to this question is not statistically significant.

Table 7: Respondents by whether the mathematics is different from school mathematics (STEM v nonSTEM)

Is the mathematics you do on your apprenticeship different?	non-STEM	STEM	Total	% of Total
Yes	80	44	124	55
No	61	39	100	45
Total	**141**	**83**	**224**	**100**



3.1.10 Additional open comments about difference in apprenticeship mathematics

From STEM apprentices:

- questions are related to relevant matters in my job
- Practical applications
- More complex, applies to specific applications within the trade.
- It relates more to my field of work and I now understand the importance of it, whereas at school I felt like there was no importance of it.

From nonSTEM apprentices:

- Not relevant at school
- More like every day maths in apprenticeship
- More work related, easier to see the point of it
- It has a purpose and it is real life. It is easier to understand when there is a situation that goes along side the math.
- The maths I do now is directly related to accounts whereas at school it was more varied as we did sums, solved problems, learnt algebra etc. Now that I can relate it to working life, I find it a lot more useful
- Calculator can be used

- We did maths part-time in college and I found it really good - I never liked maths in school but this apprenticeship has let me see it in a different light
- You don't use some of the things learnt, and don't get challenged as much
- Accountancy calculations are more confusing than school calculations
- A lot simpler/Very basic now

3.1.11 Think about the mathematics in your apprenticeship. What areas do you find particularly hard, if any?

This was an open question. Responses to this question varied from 'everything' to specifically algebra and most commonly fractions, percentages, division, ratio (ever since school), area, perimeter and volume with remarks such as 'everything I don't really understand' and 'I struggle a lot with mathematics as it is not what I enjoy'.

3.1.12 Think about the mathematics in your apprenticeship. What areas do you find particularly easy, if any?

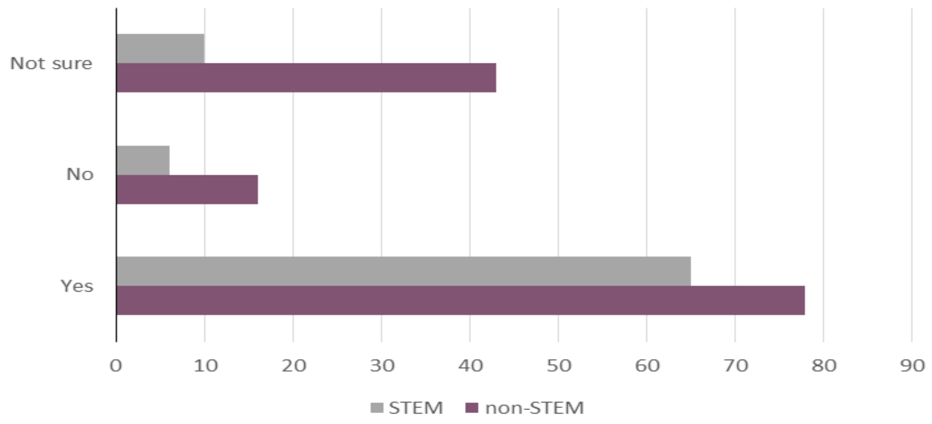
This was an open question. Responses varied from 'all/most of it' to 'none of it'. Many respondents reported finding subtracting and adding easy, with one adding 'until it gets to a lot of bigger numbers'. And one noticeably resilience response: "If I get taught how to work calculations out, I will be fine to look over my notes and it'll be easier to work other calculations"

3.1.13 Do you expect to continue to a higher apprenticeship or qualification on completion of your current apprenticeship?

Most respondents expect to continue to a higher qualification rather than not, but a surprising number (more than one quarter) were unsure (Table 8). STEM apprentices were more likely to expect to continue (80%) than nonSTEM apprentices (57%). This difference is statistically significant ($p<.001$).

Table 8: Respondents by whether continuing to a higher apprenticeship

Is the mathematics you do on your apprenticeship different?	non-STEM	STEM	Total	% of Total
Yes	79	65	143	66
No	16	6	22	10
Not sure	43	10	53	24
Total	**137**	**81**	**218**	**100**



3.1.14 Summary

In this section, the contextual and descriptive data for the cohort of apprentices who completed both the on-line and paper-based questionnaires has been given. There are some additional findings in Appendix B. Key findings demonstrate that:

- NonSTEM apprentices are much more likely to be still working on Level 2 mathematics than STEM apprentices.
- STEM apprentices are more likely than nonSTEM apprentices to report that the mathematics in their apprenticeship is harder than expected
- The majority of apprentices feel that the mathematics they do on their apprenticeship is different from school mathematics

In the next section, the mathematics anxiety indicators of the correspondents are discussed along with how mathematics anxiety interacts with the responses to the other questions.

3.2 Mathematics Anxiety Scores

Mathematics anxiety was measured using the Mathematics Anxiety Scale (MAS; Betz, 1978). The first 5 questions are positively worded and items 6 to 10 are negatively worded. We report first the overall scores by question and then we report the STEM and nonSTEM scores. Subsequently, we use total MAS score as an indicator of level of mathematics anxiety in order to compare groups.

3.2.1 Responses to individual questions

From the responses to Item 1, we found 24% of responses indicated that taking more mathematics would bother them.

Table 9: Betz Item 1 (It wouldn't bother me at all to take more mathematics classes.)

	Respondents	% of Total
Strongly agree	20	9
Agree	98	43
Undecided	53	24
Disagree	40	18
Strongly disagree	15	7
Total	**226**	**100**

From the responses to Item 2, we found 35% of responses indicated that they have not usually been at ease during mathematics tests.

Table 10: Betz Item 2 (I have usually been at ease during mathematics tests.)

	Respondents	% of Total
Strongly agree	20	9
Agree	88	39
Undecided	39	17
Disagree	65	**29**
Strongly disagree	14	**6**
Total	**226**	**100**

From the responses to Item 3, we found 27% of responses indicated that they have not been at ease in previous mathematics courses

Table 11: Betz Item 3 (I have usually been at ease in mathematics courses.)

	Respondents	% of Total
Strongly Agree	21	9
Agree	103	46
Undecided	42	19
Disagree	49	22
Strongly disagree	11	5
Total	**226**	**100**

From the responses to Item 4, we found 23% of responses indicated active worry about ability to solve mathematics problems.

Table 12: Betz Item 4 (I usually don't worry about my ability to solve mathematics problems.)

	Respondents	% of Total
Strongly agree	17	7
Agree	97	43
Undecided	59	26
Disagree	45	20
Strongly disagree	8	3
Total	**226**	**100**

From the responses to Item 5, we found 40% of responses indicated getting uptight whilst taking mathematics tests.

Table 13: Betz Item 5 (I almost never get uptight while taking mathematics tests.)

	Respondents	% of Total
Strongly agree	18	8
Agree	63	28
Undecided	54	24
Disagree	80	35
Strongly disagree	11	5
Total	**226**	**100**

From the responses to Item 6, we found 37% of responses indicated getting *really* uptight whilst taking mathematics tests.

Table 14: Betz Item 6 (I get really uptight during mathematics tests.)

	Respondents	% of Total
Strongly agree	17	7
Agree	67	30
Undecided	53	24
Disagree	71	31
Strongly disagree	18	8
Total	**226**	**100**

From the responses to Item 7, we found 38% of responses indicated that they experience a sinking feeling in response to trying hard mathematics problems. This would indicate a significant proportion of apprentices avoid harder mathematics, whether consciously or unconsciously.

Table 15: Betz Item 7 (I get a sinking feeling when I think of trying hard mathematics problems.)

	Respondents	% of Total
Strongly agree	17	7
Agree	70	31
Undecided	47	21
Disagree	74	33
Strongly disagree	18	8
Total	**226**	**100**

From the answers to Item 8, we found 26.1% of respondents indicated that they consciously experience their mind going blank and inability to think clearly when working on mathematics.

Table 16: Betz Item 8 (My mind goes blank and I am unable to think clearly when working on mathematics.)

	Respondents	% of Total
Strongly agree	18	8
Agree	41	18
Undecided	41	18
Disagree	94	42
Strongly disagree	32	14
Total	**226**	**100**

From the answers to Item 9, we found 27% of responses indicated that mathematics made them feel consciously uncomfortable and nervous.

Table 17: Betz Item 9 (Mathematics makes me feel uncomfortable and nervous.)

	Respondents	% of Total
Strongly agree	15	7
Agree	46	20
Undecided	37	16
Disagree	97	43
Strongly disagree	31	14
Total	**226**	**100**

From the answers to Item 10, we found 25% of responses indicated that mathematics made them feel consciously uneasy and confused.

Table 18: Betz Item 10 (Mathematics makes me feel uneasy and confused.)

	Respondents	% of Total
Strongly agree	14	6
Agree	43	19
Undecided	41	18
Disagree	90	40
Strongly disagree	38	17
Total	**226**	**100**

Thus, a moderately large percentage of students responded in ways suggesting the presence of mathematics anxiety by disagreeing (or strongly disagreeing) with the positively worded statements. A moderately large percentage of students responded in ways suggesting the presence of mathematics anxiety by agreeing (or strongly agreeing) with the negatively worded statements.

The results are similar to those found by Betz (1978) in measuring the students undertaking an introductory psychology course, required as part of basic educational requirements for most degrees.

3.2.2 Responses to individual questions by STEM/nonSTEM

When split by STEM/nonSTEM, the indicated levels of mathematics anxiety show a distinct difference between STEM and nonSTEM apprentices (Table 19).

Table 19: Percentages of respondents indicating mathematics anxiety by item

		Maths Anxiety (%)	STEM (%)	nonSTEM (%)
1. It wouldn't bother me at all to take more mathematics classes.	Disagree	24	25	24
2. I have usually been at ease during mathematics tests.	Disagree	35	*26	*40
3. I have usually been at ease in mathematics courses.	Disagree	27	23	29
4. I usually don't worry about my ability to solve mathematics problems.	Disagree	23	*17	*27
5. I almost never get uptight while taking mathematics tests.	Disagree	40	*32	*45
6. I get really uptight during mathematics tests.	Agree	37	*29	*42
7. I get a sinking feeling when I think of trying hard mathematics problems.	Agree	38	35	41
8. My mind goes blank and I am unable to think clearly when working on mathematics.	Agree	26	**16	**32
9. Mathematics makes me feel uncomfortable and nervous.	Agree	27	*18	*32
10. Mathematics makes me feel uneasy and confused.	Agree	25	*18	*29

*difference significant p<0.05; ** difference significant p<0.01

The consensus in the research literature is that mathematics anxiety scales have essentially two dimensions: mathematics test anxiety and anxiety about numerical calculation (Hunt, 2011).

Expressions indicative of mathematics anxiety were most common when the items concerned mathematics tests; over 37% of the respondents reported getting "really uptight" during mathematics tests in both versions of the question. Over quarter of the STEM respondents (29%) and over 40% of the nonSTEM respondents report mathematics test anxiety on all those items, and this will likely have impacted as depressed mathematics GCSE scores.

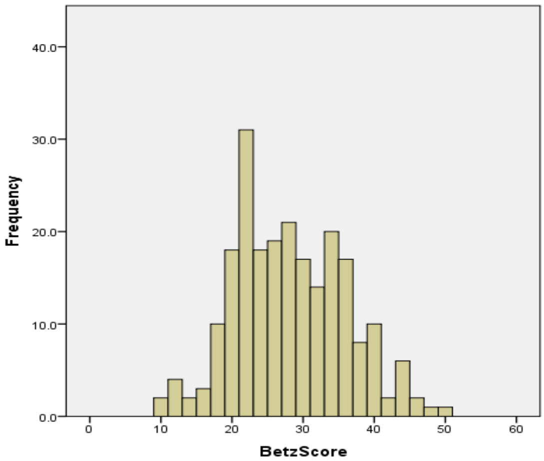
Whilst 16% STEM respondents experience their mind going blank when working on mathematics, 32% of nonSTEM respondents report this problem. This would impact on progression in mathematics.

It is interesting that the areas of mathematics most commonly cited by respondents in our survey as causing difficulty are fractions, percentages and ratio which involve numerical calculation.

3.2.3 Frequency of mathematics anxiety

Throughout the rest of this section, individual participants' mathematics anxiety scores are used by summing the responses to questions taken from the 10-item Betz Mathematics Anxiety Scale (MAS). This is indicated on the charts by the term "BetzScore".

Figure 2: BetzScores



In Figure 2, the group mean = 27.72, SD = 7.81, N = 226.

According to the scoring, 10 is the minimum BetzScore, indicating the least anxious respondents, and 50 is the highest score, indicating the most anxious respondents. One might assume that 30 would be a neutral score. However, according to the calibration of Mahmood and Khatoon (2011), this is not the case. Scores above 32 are likely to represent a tendency towards visibly high mathematics anxiety; scores above 27 are likely to represent a tendency to be anxious but this mathematics anxiety might not visibly evident. A significant proportion of the apprentices are high in mathematics anxiety.

The BetzScores from our sample indicate the possibility of an underlying normal distribution; however, there are three distinct peaks at scores 20, 28, and 34. According to the BetzScores, 30% of the respondents would likely show a tendency towards visibly high mathematics anxiety and another 19% would show a tendency to be anxious but may not show visible signs. This is indicative of 48% of the respondents being affected significantly by mathematics anxiety.

The mean BetzScore for various subgroups has been calculated, and, where appropriate, analysis of variance has been used to determine whether the difference in mean between subgroups is statistically significant, that is whether the difference could have arisen by chance rather than being indicative of a different underlying mean for each group. Significance levels of less than .05 are generally regarded as significant.

In both STEM and nonSTEM subgroups, a substantial proportion of apprentices showed anxiety towards mathematics.

Figure 3: BetzScores by STEM/nonSTEM

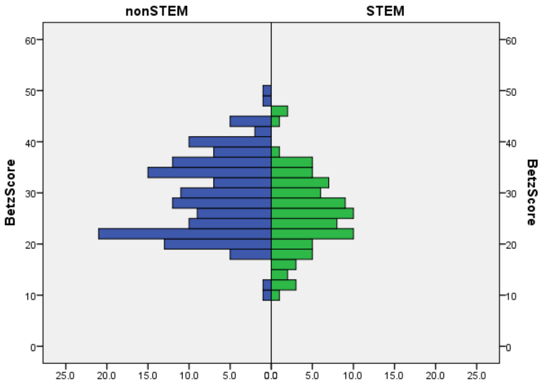


Figure 3 shows that apprentices in nonSTEM subgroup were overall more anxious (mean = 28.93, SD = 7.78) than apprentices in the STEM subgroup (mean = 25.64, SD = 7.50). It is important to note, however, there are 3 respondents from the STEM group who show high levels of mathematics anxiety.

Table 20: Mean BetzScores by STEM/nonSTEM

	Mean	N	SD
non-STEM	28.93	143	7.76
STEM	25.64	83	7.50
Total	**27.72**	**226**	**7.81**

The difference in means between STEM and nonSTEM subgroups was statistically significant (p<.01). In our sample, we found that 14 (17%) STEM apprentices were highly mathematics anxious, having a score above 32 and a further 20 (24%) with scores above 27. This is indicative of 41% of the STEM apprentices being affected significantly by mathematics anxiety (Table 21). We also found that 53 (37%) nonSTEM apprentices were highly mathematics anxious, having a score above 32 and a further 22 (15%) with scores above 27 (Table 21). This is indicative of 52% of the STEM apprentices being affected significantly by mathematics anxiety.

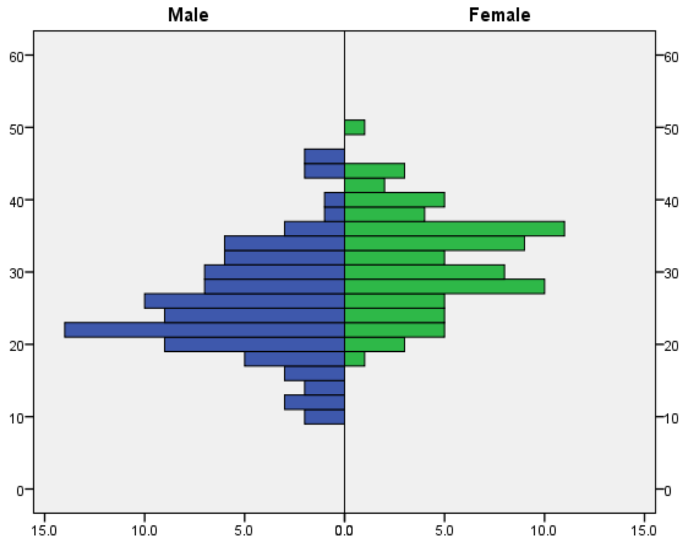
Table 21: BetzScores by low, somewhat and highly anxious and by STEM/nonSTEM, after Mahmood and Khatoon (2011)

	Non- STEM	STEM	Total	% of Total
Lower Mathematics Anxiety	68	49	117	52
Mathematics Anxious	22	20	42	19
Highly Mathematics Anxious	53	14	67	30
Total	**143**	**83**	**226**	**100**

3.2.4 Frequency of mathematics anxiety by gender

Participants' mathematics anxiety scores were then graphed by gender. Figure 4 shows that generally females report more mathematics anxiety than males.

Figure 4: BetzScores by gender



Females reported more mathematics anxiety (mean = 31.13, SD = 6.72) than males (mean =25.15, SD = 7.72); this result was statistically highly significant (F (1, 167) = 28.24, p<.001). This result indicates that the overall difference between males and females has not arisen by chance, and is also observed across other apprenticeship groups.

Table 22 presents the means and standard deviations of mathematics anxiety scores by STEM/nonSTEM and by gender.

Table 22: Mean BetzScores by STEM/nonSTEM and by gender

		Mean	N	SD
nonSTEM	Male	25.30	23	7.47
	Female	31.19	72	6.88
	Total	29.77	95	7.43
STEM	Male	25.10	69	7.85
	Female	30.20	5	4.21
	Total	25.45	74	7.75
Total	Male	25.15	92	7.72
	Female	31.13	77	6.72
Total		**27.88**	**169**	**7.86**

The difference in mathematics anxiety levels between STEM and nonSTEM subgroups is entirely accounted for by the gender imbalance. Within both groups, the mean is significantly higher (F (1,167) = 13.55, p<.001) among females (STEM females: mean = 30.20, SD = 4.21; nonSTEM females: mean = 31.19, SD = 6.88) than among males. This finding indicates that, in the main, one key issue is that of addressing mathematics anxiety explicitly to recruit and support female apprentices.

3.2.5 Frequency of mathematics anxiety by Highest Mathematics Qualification

In general, the mathematics anxiety reported by apprentices who have gained only level 1 mathematics qualification is higher (mean = 32.69, SD = 6.92) than the mathematics anxiety reported by apprentices who have gained at least level 2 (level 2: mean = 26.39, SD = 7.30; level 3: mean = 22.56, SD = 6.31) as demonstrated by Figure 5.

Figure 5: BetzScores by Highest Mathematics Qualification

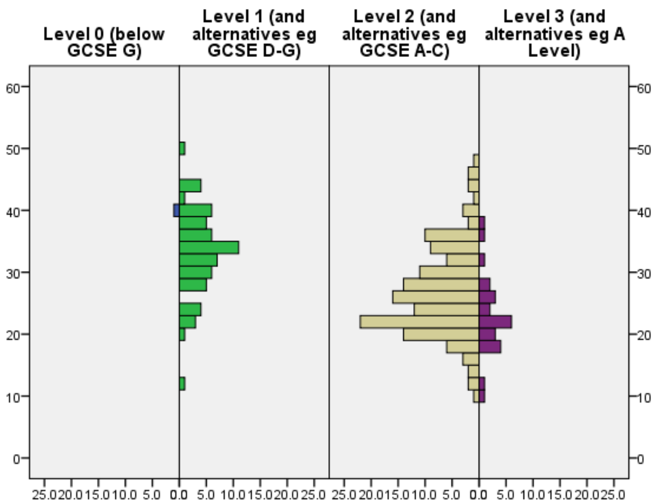


Table 23: Mean BetzScores by Highest Mathematics Qualification

	Mean	N	SD
Level 0 (below GCSE G)	39	1	.
Level 1 (and alternatives e.g. GCSE D-G)	32.69	61	6.92
Level 2 (and alternatives e.g. GCSE A-C)	26.39	139	7.30
Level 3 (and alternatives e.g. A Level)	22.56	25	6.31
Total	**27.72**	**226**	**7.81**

However, the distribution of mathematics anxiety scores at levels 2 and 3 has a long tail representing apprentices with moderate to high mathematics anxiety (Figure 6).

Figure 6: BetzScores by Highest Mathematics Qualification by STEM/nonSTEM

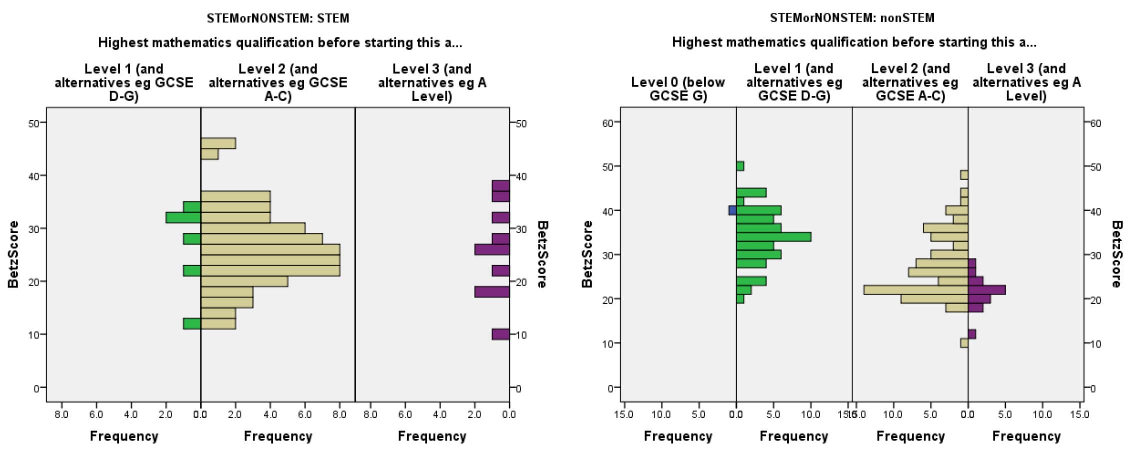


Table 24: Mean BetzScores by Highest Mathematics Qualification by STEM/nonSTEM

		Mean	N	SD
Level 0 (below GCSE G)	nonSTEM	39.00	1	.
	Total	39.00	1	.
Level 1 (and alternatives e.g. GCSE D-G)	nonSTEM	33.36	55	6.44
	STEM	26.50	6	8.71
	Total	32.69	61	6.92
Level 2 (and alternatives e.g. GCSE A-C)	nonSTEM	27.08	72	7.24
	STEM	25.64	67	7.34
	Total	26.39	139	7.30
Level 3 (and alternatives e.g. A Level)	nonSTEM	20.87	15	3.58
	STEM	25.10	10	8.61
	Total	22.56	25	6.31
Total	nonSTEM	28.93	143	7.76
	STEM	25.64	83	7.50
	Total	**27.72**	**226**	**7.81**

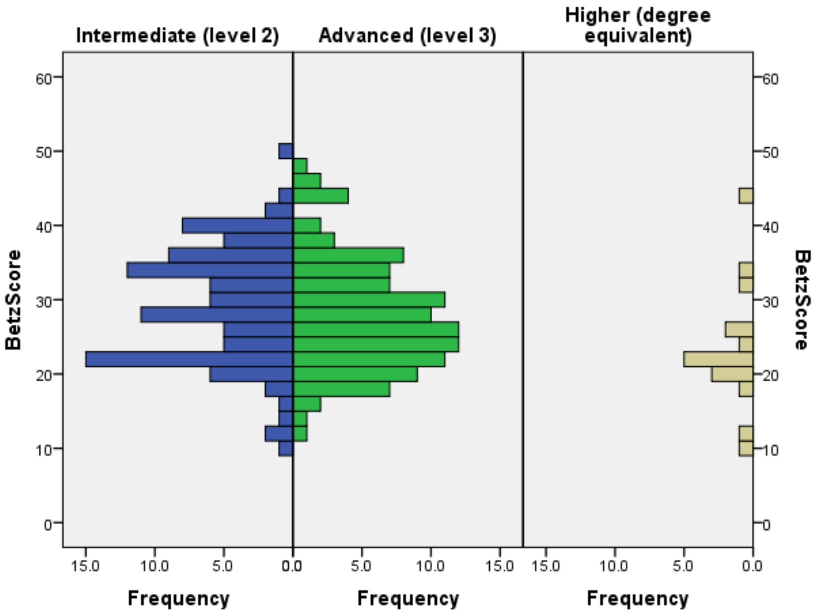
Mathematics anxiety was higher amongst nonSTEM respondents than STEM respondents, except for those apprentices who already had Level 3 mathematics. This result is statistically significant (F (3,222) = 16.85, p<.001). Interestingly the STEM apprentices who started with level 3 qualifications are more anxious (mean = 25.10, SD = 8.61) than nonSTEM apprentices (mean = 20.87, SD = 3.58). This may be a result of the fact that the number of apprentices who have gained level 3 is small in this sample. The number of STEM apprentices with level 1 is also small. The means vary significantly for the nonSTEM by highest mathematics qualification, but not for the STEM apprentices. This may be related to the small numbers of level 1 and level 3 STEM apprentices.

These findings indicate that a programme focussed on reducing mathematics anxiety for recruits who only have a level 1 mathematics qualification would have a greater impact than one focused on apprentices who already have level 2. Once recruits are mathematically resilient, they may be future STEM apprentices.

3.2.6 Frequencies by level of apprenticeship

We calculated each participant's mathematics anxiety score and plotted this against the level of apprenticeship they were studying. Figure 7 shows intermediate level apprentices who responded have a maximum mathematics anxiety score of 50 (highest possible score), and advanced level apprentices a maximum mathematics anxiety score of 48. Generally, apprentices who are studying for a higher-level apprenticeship are less mathematically anxious but also the issue of mathematics anxiety is still present in some higher level apprentices.

Figure 7: BetzScores by level of apprenticeship



Mathematics anxiety was highest amongst respondents taking a level 2 apprenticeship (mean = 28.81, SD = 7.89).

Table 25: Mean BetzScores by level of apprenticeship

	Mean	N	SD
Intermediate (level 2)	28.81	99	7.89
Advanced (level 3)	27.46	110	7.50
Higher (degree equivalent)	23.06	17	7.909
Total	**27.72**	**226**	**7.81**

Again there is a long tail of mathematically anxious apprentices at levels 2 and 3.

The differences in mathematics anxiety between levels of apprenticeship were statistically significant (*F* (2, 223) = 4.16, p<0.05). This gives an indication that those undertaking intermediate level are likely to have underachieved most in mathematics and to have potential for significant improvement when their mathematics anxiety is addressed.

Figure 8: BetzScores by level of apprenticeship by STEM/nonSTEM

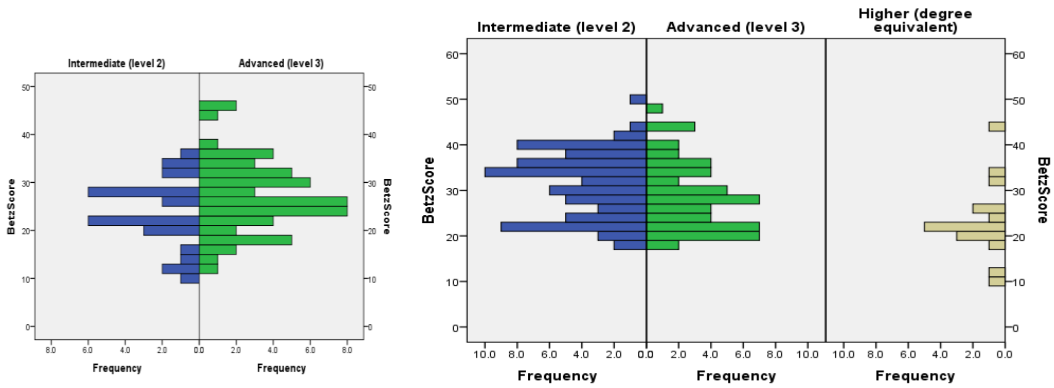


Figure 8 shows that the mean mathematics anxiety amongst nonSTEM apprentices decreases across levels. However, there is still very significant variation in the mathematics anxiety at each level of apprenticeship. The longer tail of mathematically anxious apprentices shows at levels 2 and 3 meaning that although the mean is decreasing, a significant number of apprentices are still affected by mathematics anxiety.

There are no STEM apprentices working at higher level in our sample. The number working at intermediate level is relatively small and so it is not possible to draw conclusions about how mathematics anxiety varies across levels of apprenticeship.

Table 26: Mean BetzScores by level of apprenticeship by STEM/nonSTEM

		Mean	N	SD
Intermediate (level 2)	nonSTEM	30.82	72	7.19
	STEM	23.44	27	7.25
	Total	28.81	99	7.89
Advanced (level 3)	nonSTEM	28.26	54	7.53
	STEM	26.70	56	7.45
	Total	27.46	110	7.50
Higher (degree equivalent)	nonSTEM	23.06	17	7.91
	Total	23.06	17	7.91
Total	nonSTEM	28.93	143	7.76
	STEM	25.64	83	7.50
	Total	**27.72**	**226**	**7.81**

3.2.7 Frequencies by choice of apprenticeship

Mathematics anxiety scores varied by type of apprenticeship with highest levels observed among apprentices in Retail and Commercial Enterprise (mean = 34.50, SD = 6.45) and ICT (mean = 34.00, SD = 0). This result was statistically significant (F (6, 225) = 2.99, p<.01), indicating that level of mathematics anxiety influences choice of apprenticeship to a significant extent and that the difference in mathematics anxiety scores is likely to be found in any similar group of apprentices. It indicates that the choice of apprenticeship is influenced by the mathematics anxiety and not just by chance.

Table 27: Mean BetzScore by type of apprenticeship

	Mean	N	SD
Business Administration and Law	27.63	79	7.88
Construction, Planning and the Build Environment	21.5	2	14.85
Education and Training	30.06	34	7.02
Engineering and Manufacturing Technologies	25.64	80	7.37
Health, Public Services and Care	30.54	26	7.95
Information and Communication Technology	34	1	.
Retail and Commercial Enterprise	34.5	4	6.46
Total	**27.72**	**226**	**7.81**

However, the following findings clarify this as they demonstrate that respondents' levels of mathematics anxiety are related to choice of STEM or nonSTEM apprenticeship. This might suggest that respondents who are mathematics anxious are unaware or unwilling to acknowledge the impact that their mathematics anxiety has on their lives.

3.2.8 Frequencies by amount of mathematics expected

Those who are experiencing more mathematics than expected are more mathematics anxious (mean = 29.81, SD = 7.48) than the average (mean = 27.67, SD = 7.79). Those who are experiencing less mathematics than expected are less mathematics anxious (mean = 26.90, SD = 8.65) than the average.

Table 28: Mean BetzScore by amount of mathematics expected

	Mean	N	SD
More	29.81	52	7.49
Less	26.9	49	8.65
The same	27.08	124	7.46
Total	**27.67**	**225**	**7.79**

This result was marginally statistically significant (F (2, 222) = 2.59, p<.10). This provides an indication that choice of apprenticeship was not made in the full light of mathematics expectation.

3.2.9 Frequencies by difficulty of mathematics expected

Those who are experiencing mathematics as more difficult than expected are more mathematics anxious (mean = 30.89, SD = 8.13) than the average. Those who are experiencing mathematics as less difficult than expected are less mathematics anxious (mean = 25.45, SD = 7.37) than the average. There is an indication here that choice of apprenticeship was not made in the full light of the mathematics expectations.

Table 29: Mean BetzScore by expected difficulty of mathematics by STEM/nonSTEM

		Mean	N	SD
Easier	nonSTEM	26.35	34	7.52
	STEM	24.05	22	7.09
	Total	25.45	56	7.37
The same	nonSTEM	28.28	83	7.42
	STEM	24.35	31	6.59
	Total	27.21	114	7.39
Harder	nonSTEM	34.20	25	6.79
	STEM	28.13	30	8.22
	Total	30.89	55	8.13
Total	nonSTEM	28.86	142	7.74
	STEM	25.64	83	7.50
	Total	**27.67**	**225**	**7.79**

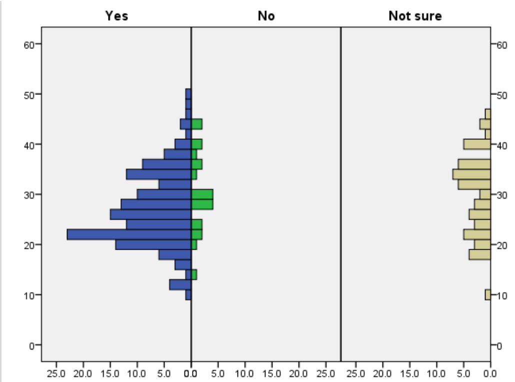
Differences between levels of difficulty of mathematics expected by STEM and nonSTEM were highly significant (F (2, 222) = 7.60, p<.001). Apprentices of both subgroups who discover the mathematics to be harder than they expected tend to be those who experience more mathematics anxiety. Further research would be needed to determine the direction of any causality.

3.2.10 Do you expect to continue to a higher apprenticeship or qualification on completion of your current apprenticeship?

Most respondents expect to continue to a higher qualification rather than not, but a surprising number (more than one quarter) were unsure. Most respondents expect to continue to a higher qualification rather than not, but a surprising number (more than one quarter) were unsure (Figure 9). Those who expected to continue to a higher apprenticeship were the least mathematically anxious (mean=26.52, SD = 7.63).

Figure 9: mean BetzScore by continuing to a higher apprenticeship

	Mean	N	SD
Yes	26.52	143	7.627
No	30.05	22	7.931
Not sure	29.68	53	7.999
Total	27.65	218	7.868



Differences between these two groups (those expecting to continue to a higher qualification and those who did not) were statistically significant (F (2,215) = 4.38, p<.01). This indicates that mathematics anxiety is affecting expectations of progression beyond the current apprenticeship.

3.2.11 Interaction between level of apprenticeship and gender

At each level of apprenticeship, mathematics anxiety was higher amongst female respondents. This correlates with the finding that fewer females are taking up STEM subjects.

Table 30: Mean BetzScore by level of apprenticeship and by gender

	Gender	Mean	N	SD
Intermediate (level 2)	Male	23.97	30	7.57
	Female	32.15	41	7.11
	Total	28.69	71	8.32
Advanced (level 3)	Male	26.05	59	7.69
	Female	29.97	31	5.55
	Total	27.40	90	7.24
Higher (degree equivalent)	Male	19.33	3	8.33
	Female	30.00	5	9.98
	Total	26.00	8	10.35
Total	Male	25.15	92	7.72
	Female	31.13	77	6.72
	Total	**27.88**	**169**	**7.85**

3.2.12 Interaction between highest mathematics qualification and gender

At each level of highest mathematics qualification, mathematics anxiety was higher amongst female respondents. This also correlates with the finding that fewer females are taking up STEM subjects.

Table 31: Mean BetzScore by highest mathematics qualification and by gender

	Gender	Mean	N	SD
Level 1	Male	29.86	14	7.912
	Female	34.37	35	6.170
	Total	33.08	49	6.940
Level 2	Male	24.24	66	7.411
	Female	28.77	39	6.046
	Total	25.92	105	7.247
Level 3	Male	24.67	12	7.808
	Female	24.00	3	2.646
	Total	24.53	15	6.999
Total	Male	25.15	92	7.72
	Female	31.13	77	6.72
	Total	**27.88**	**169**	**7.85**

For apprentices with HMQ at Level 1, the females are significantly more mathematically anxious than males (F (1, 47) = 4.54, $p < .05$). For apprentices with HMQ at Level 2, the females are also significantly more mathematically anxious than males (F (1, 103) = 10.43, $p < .005$). For apprentices with HMQ at Level 3 there is no significant difference in mathematical anxiety between males and females, but this sub-group is small in our sample.

In a linear regression analysis, the interaction effect between Gender and HMQ on Betz scores is not significant ($p = .53$).

3.2.13 Summary: Regression model

Having explored the differences between various subgroups on these issues we then employed a regression model to explore which factors counted as strongest in predicting levels of mathematics anxiety.

The most significant factors predicting level of mathematics anxiety are Gender and Highest Mathematics Qualification. Further testing of the effect of additional factors showed only perceived difficulty of the mathematics in apprenticeship gave a significant further effect. Furthermore, there is marginal significance to a possible interaction effect on BetzScores between difficulty of mathematics and highest mathematics qualification.

The findings of the regression model highlight that the most significant groups to pay attention to in terms of addressing mathematics anxiety and increasing the pool of STEM apprentices are: females and those males with lower mathematics qualifications who may have underachieved.

3.3 Mathematical Resilience scores

Mathematical resilience was measured using the Mathematical Resilience Scale. The Mathematical Resilience Scale (MRS) was designed to measure student's attitudes and beliefs in studying mathematics, constituted of three subscales: Value, Struggle and Growth. Value and Struggle scores range from 8 to 40 (8 questions). Growth score ranges from 7 to 35 (7 questions). Thus the lowest Mathematical Resilience score is 23 and the highest 115.

3.3.1 Frequencies by STEM/nonSTEM

On average, STEM apprentices are significantly (F (1, 224) = 18.66, p<.001) more mathematically resilient (mean = 89.98, SD = 8.71) than nonSTEM apprentices (mean = 84.86, SD = 8.50). However, there is still large variation in resilience scores amongst both STEM and nonSTEM.

Table 32: Mathematical resilience scores and subscale scores by STEM/nonSTEM

		Mathematical Resilience	Value	Struggle	Growth
nonSTEM	Mean	84.86	29.26	29.22	26.38
(N=143)	SD	8.50	4.48	3.10	4.37
STEM	Mean	89.98	32.23	30.50	27.25
(N=83)	SD	8.71	4.58	3.62	4.92
Total	Mean	86.74	30.35	29.69	26.70
(N=226)	SD	8.91	4.73	3.35	4.59

STEM apprentices scored significantly higher than nonSTEM in the Value subscale (F (1, 224) = 22.72, p<.001) and the Struggle subscale (F (1, 224) = 7.77, p<.01).

The difference in Growth score between STEM and nonSTEM apprentices is not significant.

This highlights that in terms of mathematic resiliency STEM apprentices are significantly more likely than nonSTEM apprentices to appreciate the value of mathematics and the need for struggle. These results are consistent with those found by Kooken et al (2013) with cohorts of similar aged university students in USA.

3.3.2 Frequencies by gender

On average male apprentices are more mathematically resilient (mean=90.12, SD =8.80) than female apprentices (mean=84.58, SD = 8.91). There remains however large variation in resilience scores amongst both male and female apprentices, i.e. there exists mathematics anxiety in both subgroups.

Table 33: Mathematical resilience scores by gender

		Mathematical Resilience	Value	Struggle	Growth
Male	Mean	90.12	31.95	30.73	27.45
(N=92)	SD	8.80	4.88	3.61	4.76
Female	Mean	84.58	28.94	29.25	26.40
(N=77)	SD	8.90	4.76	3.21	4.25
Total	**Mean**	**87.60**	**30.574**	**30.05**	**26.97**
(N=169)	**SD**	**9.24**	**5.04**	**3.50**	**4.55**

The difference in mathematical resilience between male and female apprentices is statistically significant (F (1, 167) = 16.41, p<.001).

Male apprentices scored significantly higher than female in the Value subscale (F (1, 167) = 16.33, p<.001) and the Struggle subscale (F (1, 167) = 7.81, p<.01).

The difference in Growth score between STEM and nonSTEM apprentices is not significant. Kooken et al (2013) found no significant differences in the subscales by gender.

Looking at the three subscales Value, Struggle and Growth, only the Growth scores show no significant difference between male and female apprentices. Again, this highlights that in terms of mathematical resiliency, male apprentices are more likely to be mathematically resilient, through higher Value and Struggle scores.

3.3.3 Frequencies by highest level of maths qualification

On average, apprentices with only Level 1 mathematics qualifications (or below) are less mathematically resilient (mean = 82.82, SD = 9.05) than other apprentices (group mean = 86.74, SD = 8.91). There is still large variation in resilience scores amongst apprentices at each level of HMQ which indicates that mathematics anxiety is a concern for some at each level.

Table 34: Mathematical resilience scores by Highest Mathematics Qualification

		Mathematical Resilience	Value	Struggle	Growth
Level 0 (below GCSE G)	Mean	81.00	29.00	27.00	25.00
(N=1)	SD	.	.	.	.
Level 1	Mean	82.82	28.00	28.82	26.00
(and alternatives e.g. GCSE D-G)	SD	9.05	4.91	3.40	4.23
(N=61)					
Level 2	Mean	88.37	30.91	30.15	27.30
(and alternatives e.g. GCSE A-C)	SD	8.58	4.52	2.96	4.52
(N=139)					
Level 3	Mean	87.48	33.00	29.36	25.12
(and alternatives e.g. A Level)	SD	7.77	2.99	4.75	5.41
(N=25)					
Total	**Mean**	**86.74**	**30.35**	**29.69**	**26.70**
(N=226)	**SD**	**8.91**	**4.73**	**3.35**	**4.59**

The difference in mathematical resilience between apprentices with different levels of HMQ is statistically significant ($F (3,222) = 6.06, p<.001$). Looking at the three factors Value, Struggle and Growth, the differences between both the Struggle and Growth scores show no significant difference between different levels of HMQ is apprentices. However, differences between the groups in Value scores is highly significant ($F (3,222) = 69.24, p<.001$), demonstrating that apprentices with a higher level of HMQ are more likely to value mathematics.

3.3.4 Frequencies by difficulty of mathematics

Apprentices who perceive the difficulty of mathematics to be harder than expected report less mathematical resilience (mean=84.42, SD = 10.56) than other apprentices (group mean=86.69, SD = 8.91). There is still large variation in resilience scores amongst apprentices at each level of HMQ.

Table 35: Mathematical resilience scores by expected difficulty

		Mathematical Resilience	Value	Struggle	Growth
Easier (N=56)	Mean	87.29	31.23	29.95	26.11
	SD	8.07	4.81	3.77	4.79
The same (N=114)	Mean	87.50	30.28	29.55	27.67
	SD	8.30	4.14	3.17	3.80
Harder (N=55)	Mean	84.42	29.53	29.67	25.22
	SD	10.56	5.66	3.33	5.40
Total (N=225)	Mean	86.69	30.33	29.68	26.68
	SD	8.91	4.73	3.35	4.59

The difference in mathematical resilience between apprentices who perceive the difficulty of mathematics to be harder or easier than expected or the same is not statistically significant. Looking at the three subscales Value, Struggle and Growth, only the Growth score differences are statistically significant ($F(2,222) = 6.13$, $p<.005$). Further research would be needed to explore this result.

3.3.5 Frequencies summary

Although other factors are associated with mathematical resilience, the most significant group to pay attention to in terms of addressing mathematical resilience and increasing the pool of STEM apprentices is females. Beyond that it is recommended to pay attention to developing a growth mindset and increasing awareness of the role and value of mathematics in all apprenticeships.

4 Discussion

In this section, the implications of results are discussed as they relate to each of the three research questions. It is worth noting at the outset that the majority of the respondents to the survey were undertaking level 2 mathematics functional skills; about one-third of the respondents were undertaking level 1. Thus the apprenticeship programme in general is recruiting heavily from those 38.2% students nationally who do not yet have level 2mathematics (SFR13/2013).

4.1 Research question 1 (RQ1): to what extent are STEM and nonSTEM apprentices affected by mathematics anxiety?

Results across a wide range of previous studies have indicated that mathematics anxiety occurs frequently among groups of students and that it is more likely to occur among women than among men and among students with poor high school mathematics backgrounds. Higher levels of mathematics anxiety are related to lower individual mathematics achievement (see for example, Ma, 1999; Bai, 2011; Brunye, 2013.) In this report, we suggest that mathematics anxiety is affecting both the recruitment and the progress of STEM and nonSTEM apprentices.

- Our results suggest that mathematics anxiety among apprentices (mean = 27.7, SD = 7.81) is comparable with reported school and college populations; Pajares and Urdan 1996 (High School): mean = 25.8, SD=8.7; Pajares and Urdan 1996 (College): mean = 28.0, SD = 10.8.Betz 1978, (College, Mathematics 1): mean = 26.9, SD = 7.6.

Table 36: Comparison of BetzScores with a sample of other studies

Study	Group	Mean	SD
This research 2014	Apprentices	27.7	7.81
Pajares & Urdan 1996	High School	25.8	8.7
Pajares & Urdan 1996	College	28.0	10.8
Betz 1978	College Maths 1	26.9	7.6

- Our results suggest that about 30% of apprentices are likely to be visibly anxious about mathematics and another 19% would show a tendency to be anxious but may not show visible signs.
- Our results suggest that higher levels of mathematics anxiety amongst apprentices are associated with lower mathematics achievement; mathematics anxiety tends to be higher among apprentices with Level 1 mathematics backgrounds (mean=32.69, SD = 6.92) than Level 2 mathematics backgrounds (mean=26.39, SD = 7.30). However, the distribution of mathematics anxiety at levels 2 and 3 has a long tail representing apprentices with high mathematics anxiety. Based on the literature, it is likely that the mathematics anxiety is causing underachievement in mathematics (Ma, 1999; Cates & Rhymer, 2003).
- Our results indicate that mathematics anxiety is more likely to occur amongst female apprentices (mean= 31.13, SD = 6.72) than among male apprentices (mean=25.15, SD = 7.72).

- Our results indicate significant presence of mathematics anxiety in both STEM (mean = 25.64, SD = 7.50) and non-STEM groups (mean = 28.93, SD = 7.76). We found it interesting that there were some very anxious individuals in the STEM group, with mathematics anxiety scores of over 40.
- Our results indicate that mathematics anxiety is more prevalent amongst nonSTEM apprentices than amongst STEM apprentices. Our results suggest that about 17% STEM apprentices would be visibly anxious about mathematics and a further 24% would show a tendency to be anxious but may not show visible signs. Our results suggest that about 37% nonSTEM apprentices would be visibly anxious about mathematics and a further 15% would show a tendency to be anxious but may not show visible signs of mathematics anxiety.

The difference between mean mathematics anxiety scores of STEM and nonSTEM apprentices is statistically significant, but it is associated with the higher prevalence of mathematics anxiety among females than males, and the fact that females are more likely to be studying non-STEM apprenticeships than are males. Our research showed that females are more likely to choose non-STEM apprenticeships and, since there is research evidence to show females are generally more mathematically anxious than males, the higher levels of mathematics anxiety in non-STEM apprentices is an expected result. Non-STEM apprenticeships tend to have lower mathematics qualification on entry. Thus, if an apprentice has underachieved mathematically, it would seem more likely that they would take a non-STEM apprenticeship.

- Our results indicate that mathematics anxiety is significant in over 30% of the apprenticeship population. About a quarter of STEM and nonSTEM respondents would be bothered about taking more mathematics classes. Over a third of both groups reported ‘a sinking feeling when trying hard problems’. This gives an indication of levels of mathematics avoidance, both in general and of perceived hard questions. This would impact on progression in mathematics.

Higher mathematics anxiety is consistently related to lower mathematics performance (Hembree, 1990). It is established in other research (Brunye, 2013; Beilock and Carr, 2005) that mathematics anxiety is highly likely to be hindering well-being and progress.

“Students with high math anxiety avoid math exposure in both daily life (e.g., calculating a tip at a restaurant) and formal educational coursework (e.g., calculus), ultimately resulting in lower exposure to math, reduced practice using mathematics principles, and reduced workforce math competence. Because time-pressured testing situations characterize many college mathematics courses, math anxiety becomes a primary impediment to students' academic success.” Brunye, 2013

Highly mathematics-anxious students devote a considerable amount of cognitive and attentional resources towards intrusive thoughts, rather than to the demands of mathematical tasks, resulting in underperformance (Ashcraft, 2002; Beilock & Carr, 2005).

''Individuals with high mathematics anxiety tend to perform poorly when presented with mathematics stimuli (Cates & Rhymer, 2003) with a population correlation estimated at -.27. This means that ... measures (or treatments) that resulted in movement of a typical student in the group of high mathematics anxiety into the group of low mathematics anxiety would be associated with improvement of the typical student's level of mathematics achievement from the 50th to the 71st percentile'' (Ma, 1999, p. 528)

Thus if mathematical anxiety is addressed, the apprentices' level of mathematics achievement is likely to improve dramatically.

4.2 Research question 2 (RQ2): to what extent does mathematics anxiety affect choice of apprenticeship?

About a quarter of the respondents reported that feelings about mathematics had played a conscious role in their choice of apprenticeship. For many others, the decision may have been made on a less explicit basis.

The difference between mathematics anxiety scores of STEM and nonSTEM apprentices suggests a strong connection between mathematics anxiety and choice of apprenticeship. Mean mathematics anxiety scores also varied by type of apprenticeship. This result was statistically significant. This indicates that level of mathematics anxiety influences choice of apprenticeship to a significant extent.

The difference between mathematics anxiety scores of those who know whether they will continue to a higher level apprenticeship or not would suggest a clear association between mathematics anxiety and progression beyond the current apprenticeship.

Results suggest that:

- females who have higher mathematics anxiety are choosing nonSTEM over STEM apprenticeships.
- apprentices who have underachieved at mathematics in school, possibly through mathematics anxiety, are more likely to choose nonSTEM apprenticeships.
- for some apprentices, once they are recruited and engaged, the mathematics they encounter is significantly different from school mathematics. Comments indicate that the contextual nature of apprenticeship mathematics is much appreciated.
- higher levels of mathematics anxiety are associated with apprentices who experience harder mathematics than expected.

Individual differences in math anxiety may influence many intellectually capable students in their decision to opt out of higher mathematics education, ultimately decreasing enrolment in mathematics courses, and, reducing work force competencies (Ashcraft, 2002). We have asserted elsewhere that 23% of the national population is underachieving in mathematics and that a large proportion of that underachievement is down to mathematics anxiety. Thus, there are two new sources of STEM apprentices: females, and, those who are underachieving in mathematics at school. These are perhaps what might be described as the "lost" STEM apprentices.

In terms of recruitment, the results of the survey indicate that a coaching programme focussed on recruits who have only gained level 1 mathematics qualification would have greater impact than a coaching programme focussed on recruits with an existing level 2 mathematics qualification. Should potential recruits develop mathematical resilient, they may be future STEM apprentices.

4.3 Research question 3 (RQ3): to what extent are STEM and nonSTEM apprentices mathematically resilient?

On average, STEM apprentices are marginally more mathematically resilient (mean=89.98, SD = 8.71) than nonSTEM (mean=84.86, SD = 8.50). There is large variation in resilience scores amongst both STEM and nonSTEM apprentices.

On average, male apprentices are more mathematically resilient (mean=90.12, SD = 8.80) than female apprentices (mean=84.58, SD = 8.90). There is large variation in resilience scores amongst both male and female apprentices.

On average, apprentices with only Level 1 mathematics qualifications are less mathematically resilient (mean=82.82, SD = 9.05) than other apprentices (group mean=86.74, SD = 8.91). There is large variation in resilience scores amongst apprentices at each level of HMQ.

On average, apprentices who perceive the difficulty of mathematics to be harder than expected report less mathematical resilience (mean=84.42, SD = 10.56) than other apprentices (group mean=86.69, SD = 8.91). There is large variation in resilience scores amongst apprentices at each level of HMQ.

4.4 Conclusions

Mathematics anxiety exists at a significant level amongst apprentices in the UK. Overall, our findings show that the level of mathematics anxiety varies with whether the apprentice is on a STEM or nonSTEM programme, whether they are male or female and with their highest mathematics qualification at the start of the programme.

This has significant implications for recruitment of apprentices and for how a programme might be tailored to be more successful at the recruitment and progression of the currently mathematically anxious.

In apprenticeships, mathematics is usually experienced in context; it is also a fresh start where it does not matter in cognitive terms what your previous mathematics experience is – individuals with mathematical resilience including a growth mindset will be able to develop the necessary mathematical skills, provided mathematics anxiety is addressed explicitly where it has taken hold. However, previous mathematics experience will affect the apprentices' responses to any new experience of mathematics.

There is current significant national policy concern relating to attainment of Mathematics at level 2 from amongst the age range cohort and steps have been taken and funding incentive measures put into place for the prioritising of mathematics level 2 attainment in post 16 provision where learners do not achieve such attainment pre 16. Mathematics anxiety has been shown to be a significant contributing factor amongst this cohort.

There is a large pool of people (roughly 23% of the population) who do not have mathematics level 2. It appears from this and other research that this pool of people are capable of attaining level 2, provided the mathematics is in context and that mathematics anxiety is addressed.

For many people, the problem "is only in mathematics ..."; we suggest this is a reason to address the mathematics problem and test the conjecture that, by addressing mathematics anxiety and avoidance we will increase both recruitment and progress. For all apprentices especially those following STEM apprenticeships.

Identifying reliable and tractable methods for addressing math anxiety is critical to increasing student participation in higher mathematics education, increasing mathematics competencies, and supporting math-related career decisions in science, technology, engineering, and mathematics (STEM) disciplines (Ashcraft & Krause, 2007).

We wanted to find out whether mathematics anxiety in the Apprenticeship sectors (both STEM and nonSTEM) is as prevalent as the presence of mathematics anxiety in the general population. Since the clear indications are that it **is**, it is time to explore some contributory solutions:

"Best educational practices for enhancing math competency in HMAs is not to generate costly math courses specifically for the HMAs (Gresham 2007) nor is the best method likely to be one that focuses solely on eliminating one's initial anxiety response (for a review of these and other approaches, see especially Hembree 1990). Instead, classroom practices that help students learn how to marshal cognitive control resources and effectively check one's math-related anxiety response once it occurs—but before it has a chance to reduce actual math performance—will likely be the most successful avenue for reducing anxiety-related math deficits. 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." (Lyons and Beilock 2013)

We thank all those who took part in this survey.

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Appendix A: survey questions

A1: Measuring Mathematics Anxiety Using MAS (Betz)

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. 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.

Note: Response categories are as follows: SA or A = strongly agree or agree; U = undecided; D or SD = disagree or strongly disagree.

Betz, N. E. (1978). Math Anxiety Scale

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Source: Betz, Nancy E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. Journal of Counseling Psychology, Vol 25(5), 441-448. doi: 10.1037/0022-0167.25.5.441

A2: The Mathematical Resilience Scale (MRS) (Kooken et al 2013)

- Maths is very helpful no matter what I decide to study.
- Struggle is a normal part of working on Maths.
- If someone is not good at Maths, there is nothing that can be done to change that.
- Maths can be learned by anyone.
- Everyone struggles with Maths at some point.
- Maths is essential for my future.
- If someone is not a Maths person, they won't be able to learn much Maths.
- Good Mathematicians experience difficulties when solving problems.
- People who work in Maths-related fields sometimes find Maths challenging.
- People are either good at Maths or they aren't.
- Everyone makes mistakes at times when doing Maths.
- Maths will be useful to me in my life's work.
- People in my peer group sometimes struggle with Maths.
- Everyone's Maths ability is determined at birth.

- People who are good at Maths may fail a hard Maths test.
- Knowing Maths contributes greatly to achieving my goals.
- Having a solid knowledge of Maths helps me understand more complex topics in my field.
- Some people cannot learn Maths.
- Learning Maths develops good thinking skills that are necessary to succeed in any career.
- Making mistakes is necessary to get good at Maths.
- Thinking mathematically can help me with things that matter to me
- Only smart people can do Maths
- It would be difficult to succeed in life without Maths.

Kooken, J. et al (2013). *Mathematics Resilience Scale*

Source: **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.

A3: Questions about choice of apprenticeship?

For the first part of each question below please circle one answer.

- Did your feelings about mathematics affect your choice of apprenticeship:

  a lot / a little / not at all?

  In what way?.. ....

- Think about when you chose your apprenticeship. Is the **amount** of maths you use now in your apprenticeship more / less or the same as you expected?

  more/ less /the same

  Any comment? ………

- Think about when you chose your apprenticeship. Is the **difficulty** of maths you use in your apprenticeship harder/ easier or the same as you expected?

  harder/ easier /the same

  Any comment? ………

- Is the mathematics you do on your apprenticeship different from the mathematics that you did in school?

  Yes/no

  Please give an example of how it is different.
  ……

- Think about the maths in your apprenticeship. What areas do you find particularly hard, if any?

  ………

- Think about the maths in your apprenticeship. What areas do you find particularly easy, if any?

A4: Contextual questions

- Gender: male/female
- Apprenticeship:
- Level of Apprenticeship:
  Intermediate (level 2)
  Advanced (level 3)
  Higher (degree equivalent)
- Highest mathematics qualification:
  Level 1 (and alternatives eg GSCE D-G)
  Level 2 (and alternatives eg GCSE A-C)
  Level 3 (and alternatives eg ALevel)
  Other
- Grade on Above:
- Location: which training provider and which employer
- Plans for progression – do you expect to continue to a higher apprenticeship or qualification on completion of the current apprenticeship
- How many years have you been an apprentice?
- What qualifications are you doing as part of your apprenticeship?

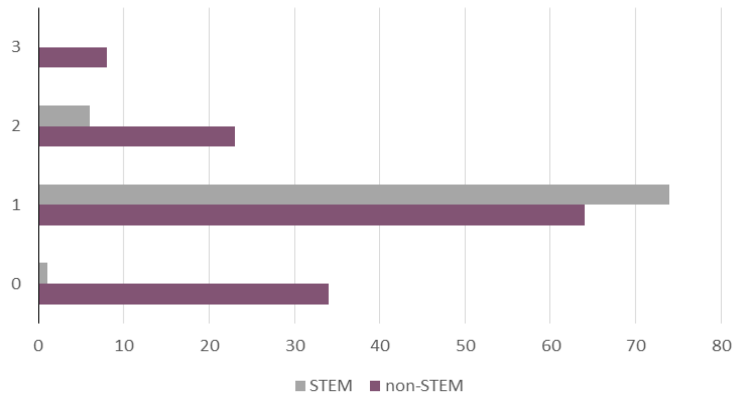
Appendix B: Further contextual data

How many years have you been an apprentice?

The modal response was 1 year; a few respondents mis-read the question and used months. This is indicative of a difficulty with mathematics. The data has been cleaned when it is clear what was intended, and omitted if it was not clear.

Table 37: Respondents by how many years as an apprentice (STEM v nonSTEM)

Years	Non- STEM	STEM	Total
0	34	1	35
1	64	74	138
2	23	6	29
3	8	0	8
Total	**129**	**81**	**210**

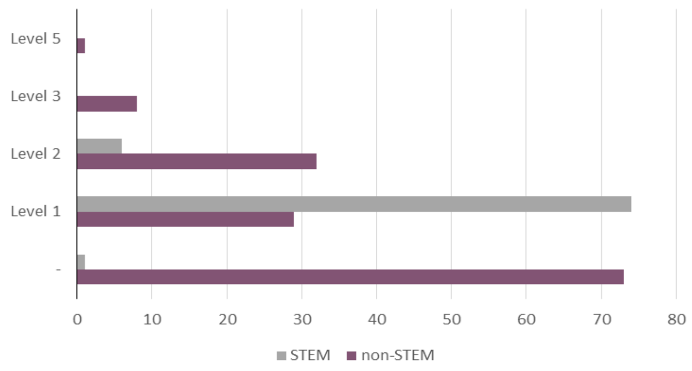


What qualifications are you doing as part of your apprenticeship?

The majority of the respondents were undertaking level 2 functional skills; about one-third of the respondents were undertaking level 1.

Table 38: Respondents by what level of functional skills currently working towards (STEM v non-STEM)

	non-STEM	STEM	Total
-	73	34	107
Level 1	29	8	37
Level 2	32	40	72
Level 3	8	1	9
Level 5	1	0	1
Total	**143**	**83**	**226**



STEM apprentices are much less likely to be working at Level 1 than nonSTEM apprentices.