

A STATISTICAL ANALYSIS ON THE FACTORS INFLUENCING MATHEMATICS ANXIETY IN UNDERGRADUATE STUDENTS OF MATHEMATICS AND ENGINEERING

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Abstract

Mathematics Anxiety (MA), the ‘phobia of numbers’, is related to poor performance in Mathematics. There are numerous studies that discuss a wide range of factors affecting Mathematics Anxiety in students at primary and secondary schools. Furthermore, there are some studies looking into MA in students of Psychology, Engineering and Nursing at a Higher Education level, see, for example (Alves et al. 2016; McMullan et al. 2012) and more references therein. However, we believe that this is the first work on MA in undergraduate students of Mathematics. Consequently, our purpose is to determine whether factors such as gender or ethnicity affect MA. Our main results are that there are significant differences between male and female students; there is a significant difference among students with three siblings or more, compared to students who have two siblings or less. Finally, we discuss the significant difference between the gender of the main family figure providing Mathematics support amongst students with a British and Non-British background.

Keywords: *Mathematics anxiety, ethnicity, gender, mathematics, higher education.*

1. Introduction

In the UK there has been an increasing need for employees with a strong mathematical background, yet there has been a decrease in the number of students who chose to continue to study Mathematics post-16. Comparatively, Japan has 84% of its students continuing with Mathematics post-16 whereas the UK only has 14% (Mansell, 2010). The reason behind the low levels of continuation of Mathematics has been associated with the growth of a “Mathematics Anxiety” (hereafter MA) culture within the UK (Frenzel et al., 2010; Sherman and Wither, 2003). MA is defined as ‘a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems’ (Richardson & Suinn, 1972). There are some causal factors which have been researched in other studies including; gender (Devine et al., 2012), ethnicity (Huntsinger et al., 2000) and family influences (Gonzalez-DeHass et al., 2005). Few articles contain data based in the UK and lacked discussion between the link of the listed factors above in British schools and universities. This study will research whether there are any correlations between the factors listed and whether they have a direct influence on MA in students of Mathematics and Engineering at a Higher Education institution within the UK.

1.1. Gender

There has been an extensive amount of research which has studied the differences between how males and females respond to MA. Many studies have determined that girls exhibit higher MA than boys (Hill et al., 2016, Devine et al., 2012, Meece et al., 1990). This suggests that fewer females will continue with Mathematics post-GCSE. In 2016 the ratio of men to women taking A-level Further Mathematics within the UK was 72.5:27.5 (Kirk, 2017). As a result, numbers further deplete at university where females who studied Mathematics and Engineering in 2013-14 were approximately 30% and 10% respectively (timeshighereducation.com, 2018). This infers that females experiencing MA are not only less likely to continue with Mathematics, but also avoid pursuing careers requiring quantitative skills (Hill et al., 2016).

This study will focus on gender-related findings in older students of Mathematics. While there has been research conducted on gender and MA in both primary (Vukovic et al., 2013, Newstead 1998) and secondary schools (Catsambis, 1994, Frenzel et al., 2010), there is little research on the impact post-GCSE. Consequently, this study will investigate gender-related findings on MA in Higher Education. Current findings suggest that despite the generally higher levels of MA in females, this has not made an impact on their performance. In fact, studies have proposed that their performance is similar to males and in reality, females have a greater mathematical potential than males (Devine et al., 2012). Little research contradicts this statement. However, Tella (2007) found that there was no significant relationship between academic achievement in gender. It was stated that in comparison to males, females were underperforming in Nigeria leading to the discussion of gender differences and attitudes in non-British cultures within the UK.

1.2. Ethnicity

In recent years, the migrant population has risen by approximately 565,000 since 2011 (BBC News, 2015). The resulting multi-cultural society has led to a range of different beliefs and attitudes towards Mathematics. This can have both positive and negative effects in one's development in Mathematics which may be a causal factor to MA. Positive aspects include diverse cultural beliefs towards Mathematics. For example, Huntsinger et al. (1993-1997) explained how Eastern countries understand the importance of enforcement of Mathematics from an early age. Ultimately, this will be reflected onto the child in their schooling environment. Huntsinger (1993-1997) studied whether different parental attitudes towards Mathematics could prevent the development of MA by comparing European American parents with Chinese American parents. Results suggest that parental practice of early training and discipline influences children's later performance in Mathematics. It was found that Chinese American interactions were longer with a greater emphasis on Mathematics. Thus, encouragement from parents was shown to be a great factor towards positive performance.

1.3. Family influences

Parents perceptions of the importance of Mathematics and students valuing Mathematics are positively correlated (Frenzel et al., 2010). This indicates that parents have the ability to aid their child's MA by supporting them. However, if they do not use their influence responsively, children may not perform well, possibly leading to MA. Some studies have shown that parents have pre-conceptions of their child's mathematical ability (Jacobs, 1991). These parental assumptions include gender stereotyping where their expectations are based on the career choice their child may be likely to proceed with. Hence, assumptions were not based on their child's achievement. Additionally, if parents display little confidence towards their child's mathematical ability, it can lead to MA due to poor self-esteem and a lack of motivation.

This study will research whether students in the UK who are from other cultures experience MA and if this is correlated with the support they may have received from their parents'. This will be explored by measuring whether students of Mathematics and Engineering received emotional support and whether they received support with their Mathematics work. Hence, developing their own attitudes in correlation with their personal heights of self-efficacy.

2. Methodology

A questionnaire was designed specifically to investigate whether gender differences, ethnic diversity and parental support amongst other factors had an effect on MA. An altered version of the official MAS-UK was included alongside a self-created version which was aimed to explore their confidence and general feeling towards Mathematics.

The opening section of the questionnaire enquired about general information in order to assist with potential causal factors. For example, the purpose of asking how many siblings a student had could influence levels of parental support. This could be due to many factors, including potential comparisons or even lack of time for support. On the contrary, this could be favourable for the participant to have a greater number of siblings, as they may support each other. Additionally, if students did have parental support a follow up question determined which parent supported them, if not both. This was related to the question of gender differences in MA.

Following the questionnaire there were two altered versions of the official MAS used in the UK (Hunt, Clark-Carter and Sheffield, 2011). This MAS described the act of Mathematics in everyday life and responses determined how anxious students may or may not feel doing these tasks. The reasons for these few modifications was to tailor them towards the target audience, undergraduates of Mathematics and Engineering. Observing the original list from Hunt et al. (2011), questions which were believed to be

irrelevant were removed, such as “counting the number of people in a room”. However, using everyday Mathematics may be sometimes challenging for students as they no longer have non-calculator assessments and so may be out of practice. As Mathematicians and Engineers were likely to have a different level of ability in Mathematics, explicit questions were designed dependent on the subject they studied, although these differences were very minor.

This questionnaire researched some factors that involved questions that people may find too private to share. One example when this was applied was when questions regarding parents were asked. It was discussed that not all participants would have two parents, some may have one parent and equally they may have more than two. Hence, it was stated within the questionnaire for the student to decide who the two most prominent parental figures during their childhood were, and to ignore any questions concerning parent 2 if applicable. Moreover, it was discussed that some people may not have heteronormative, or nuclear, families but have same sex parents. To ensure this topic was covered sensitively, instead of labelling parents as mother and father, they were categorised as “parent 1” and “parent 2”. As one of the contributing factors under investigation was whether the gender of the parent had any relation to MA in the student, the gender of parent 1 and 2 was asked, but a “prefer not to say” option was also available.

Furthermore, the discussion of ethnicity arose as a recurring theme when researching MA. General attitudes towards Mathematics in the West has allowed it to become ‘socially acceptable in admitting to having a lower ability with numbers, in contrast to core skills such as reading and writing’ (Chinn, 2009: 1). As one’s ethnicity can be particularly broad, the response part of the questionnaire regarding ethnicity was altered to be specific for this study, focusing on differences between the East and West. Additionally, the questions based on ethnicity were expressed in a way that the participant could select the ethnic group they believed to be most affiliated with. This was to eliminate the possibility of someone not knowing their “official” ethnicity due to factors such as having a background of multiple heritages.

3. Analysis and results

We have designed two main outcome variables. The first is MAS which is based upon the scores of the MARS questionnaires published by Hunt et al., (2011) with some adaptations for undergraduate students of Engineering and Mathematics. The second one is MC which is based on the score of an original questionnaire which intends to study the confidence levels at the time of dealing with Mathematics. Let us note that there is a statistically significant relationship between these two outcome variables (Spearman’s rho = 0.569, n=102, p-value<0.001). This was an expected outcome as it is common for students who lack confidence often experience anxiety.

As both MAS and MC are associated, we are only going to focus on investigating which factors have an effect on MC. However, the variable MC does not follow a normal distribution and hence a linear regression cannot be applied. Then, we transform the variable MC into a new binary variable, MCB, with values: ‘0 =confident’ and ‘1=not confident’. The percentile 65 of the distribution of MC was decided as a threshold value between confident and not confident, since the mean, percentile 50 is understood as the normal levels of confidence.

Table 1. Means and Standard deviations by level of the factors Gender and Number of Siblings.

Variable	N	Mean	S.D.
Males	76	26.61	8.81
Females	26	30.04	6.39
No siblings	9	26.44	6.29
1-2 siblings	72	29.33	8.39
3-4 siblings	18	21.83	6.64
5-6 siblings	3	21.33	6.03

From Table 2 we can see that the factors Gender, Number of Siblings and the interaction factor Parent Ethnicity*Parent Support Gender are significant with a 95% level of confidence. This implies that there are significant differences among the levels of each of the factors. In particular, by assessing the MC values it can be stated that males score approximately 3.5 points on average less than females.

Furthermore, students with more than 3 siblings happen to score much lower than students with two or less siblings.

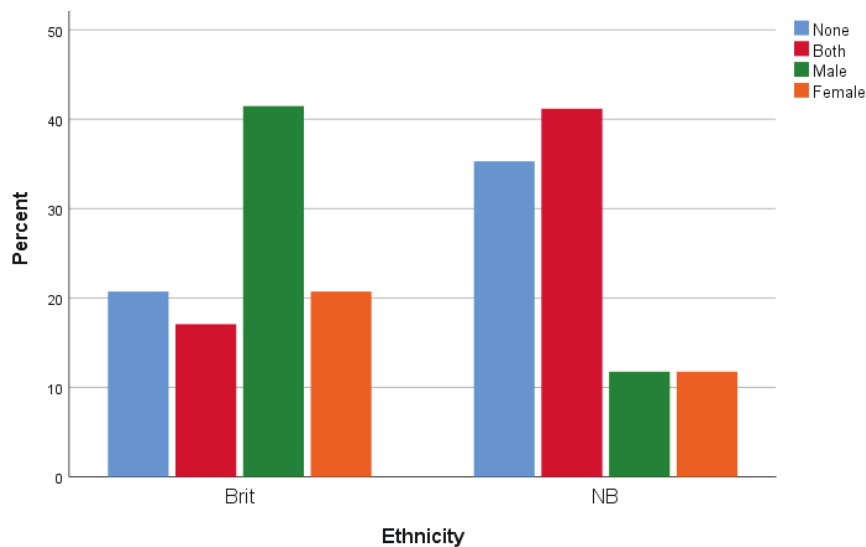
Table 2. Output of the Logistic Regression with MCB as the response variable.

Variable	B	SE	p Value	OR	95% C.I.
(Constant)	-2.06	0.74	.005		
Gender	1.507	0.632	0.017	4.515	1.31 – 15.59
Ethnicity	-0.280	0.872	0.748	0.756	0.14- 4.17
Year	-0.178	0.400	0.656	0.837	0.38 – 1.83
Number of Siblings	-2.173	0.678	0.001	0.114	0.03 – 0.43
Parent Ethnicity	2.224	1.141	0.051	9.243	0.99 - 86.53
Parent Support	0.289	0.652	0.658	1.335	0.37 – 4.79
Parent Support Gender	0.369	0.332	0.266	1.447	0.75 – 2.78
Student Motivation	-0.147	0.086	0.089	0.864	0.73 – 1.02
Subject	-0.423	0.890	0.635	0.655	0.12 – 3.75
Age	0.178	0.117	0.129	1.195	0.95 – 1.50
Parent Ethnicity*Parent Support Gender	-1.237	0.530	0.020	0.290	0.10 – 0.82

Model $\chi^2 = 20.161, df = 12, p = .259$

Finally, the differences across the sample regarding the significant factor Parent Ethnicity*Parent Support Gender are illustrated within Table 3. Here, we can appreciate that students from a British background have received mathematical support mainly from a male figure, whereas students from other backgrounds have either received equal support from both male and female parents or did not receive any support at all.

Table 3. Bar chart explaining the relationship between parent ethnicity (Brit = British vs. NB = Non British).



4. Conclusion

Mathematics Anxiety in undergraduate students of Mathematics and Engineering has been shown to be affected by the factors: gender, number of siblings and the interaction factor of parent ethnicity*parent support gender. Students from a British background received support predominantly

from a male family figure. This may be a potential cause of the gender unbalance in Engineering and Mathematics degrees and should be subject to further research.

As an application of this research, the Education policy should guarantee training on prevention of MA for parents, in order to reduce the parental support gender gap. Moreover, this intervention may lead to a reduction of the gender balance in undergraduate students pursuing a STEM degree.

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