Chapter #13

THE IMPACT OF THE ETHNICAL BACKGROUND AND THE NUMBER OF SIBLINGS ON THE SCORES OF MATHEMATICS ANXIETY

A study on Mathematics Anxiety of 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, Rodrigues, Rocha, & Coutinho, 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, Goetz, Pekrun, & Watt, 2010). 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 such as gender (Devine, Fawcett, Szűcs, & Dowker, 2012), ethnicity (Huntsinger et al, 2000) and family influences (Gonzalez-DeHass,Willems, & Holbein, 2005). Wilkinson and Pickett (2009) identify the UK to be one of the most unequal of societies in the world and so this study will also take into consideration the diversity gaps within the factors listed. There were very few articles that contained data which was based in the UK, and lacked discussion between the link of these factors in British schools and universities. This study will research whether there are any correlations between these factors 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 focused on how males and females respond to MA. Many studies in elementary education have determined that girls exhibit higher MA than boys (Hill et al., 2016, Devine et al.,2012, Meece, Wigfield, & Eccles, 1990). This suggests that fewer females will continue with Mathematics post secondary education. In 2016 the percentage of women taking A-level Further Mathematics within the UK was only 30% (FMSP, 2016). 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).

The current 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, Roberts, & Green Wright, 2013, Newstead, 1998) and secondary schools (Catsambis, 1994, Frenzel et al., 2010), there is little research on the impact post secondary education. Consequently, this study will investigate gender-related findings on MA in Higher Education. Current findings at secondary level education 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 at secondary level education. It was stated that females were underperforming compared to males 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, Jose, Larson, Balsink Krieg, and Shaligram (2000) 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 et al. (2000) studied whether different parental attitudes towards Mathematics can prevent the development of MA by comparing American parents with Chinese Americans parents. Results suggest that parental practice of early training and discipline influences children's later performance in Mathematics, as 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 were 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 have received support with their Mathematics work. Hence, developing their own attitudes in correlation with their personal heights of self-efficacy.

2. METHOD

2.1. Participants and procedures

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. This was a paper questionnaire which was distributed amongst Mathematics and Engineering students in lectures.

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, & 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 more challenging for students as they no longer have non-calculator assessments and so may be out of practise. 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.

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). 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 three main outcome variables. The first and the second ones are based upon the scores of the MARS questionnaires published (Hunt et al, 2011) with adapted independently to students of undergraduate programmes of Mathematics and Engineering. Since we have one scale MAS for Engineering and one MAS for Mathematics, we will denote these dependent variables respectively MASE and MASM. The third 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 linear relationship between MASE and MC (Pearson's $r = 0.621$, $n=50$, p-value < 0.0005), and also between MASM and MC (Pearson's $r = 0.531$, $n=50$, p-value < 0.0005). In both cases, the variables are positively correlated. As MASM and MASE are linearly related to MC, we will consider MC as the only dependent variable.

We are interested in identifying students with Mathematics Anxiety. Therefore, the outcome of MC must be transformed into a binary variable which discriminates between confident and not confident. 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, males score approximately 3.5 points on average less than females on MC score. Furthermore, students with more than 3 siblings happen to score much lower than students with two or less siblings, as we can see from Table 1.

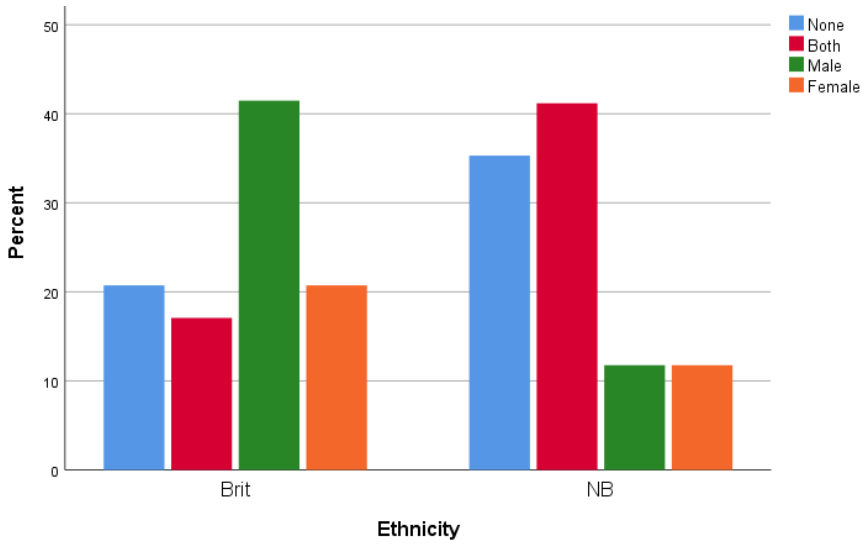
Table 2.
Output of the Logistic Regression with MCB as the response variable.

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 with 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 support equally by both male and female or not received any support at all.

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



4. DISCUSSION

4.1. Gender

As expected there was a gender gap in students who had MA despite studying mathematics or engineering at degree level. There are many factors which could influence this result but the definite reasonings still appear to be unclear. One possible reason could be that in recent years there has been a development of a more 'open' culture. This includes social issues arising such as it being 'taboo' for men to talk about their feelings and admit to 'feeling anxious' as it indicates a 'lack of masculinity' (Charteris-Black & Seale, 2009). This has stemmed from the increase of men taking their lives in recent years; national statistics show that since around 1990, men have been at least three times as vulnerable to death from suicide as women. (Ons.gov.uk, 2018). Hence, it may be that males experience MA but feel that they cannot admit to this. This is supported as there is current evidence that suggests mental illness, including anxiety in men remains both under-diagnosed and misunderstood by society (Rawala, 2018).

Another figure which was expected within this research was the low number of female students studying engineering. This was apparent when the ratio of males to females in a first year engineering class was 21:1 respectively. This has recently been highlighted within the UK as a major problem due to the contribution engineering makes to the British economy. 'Enabling women to meet their full potential in work could add as much as $28 trillion to annual GDP in 2025' (Woetzel et al., 2015). In attempt to prevent this becoming a further problem there has been a great emphasis in STEM subjects at school and recruiting more women by eliminating the threat of the stereotype and introducing more female oriented interventions such as the Quadcopter challenge (*Mathematics Anxiety and Engineering*, Contemporary research in mathematics anxiety and emotions 2018, unpublished work).

4.2. Ethnicity

There were no significant associations between ethnicity and MA itself, however this could be due to the fact that as there was a limited sample where very few students were of the same ethnic minority. Hence, when ethnicity was categorised it was condensed so that students were either British or Non-British students. Despite ethnic minority being reduced to only two categories there was still no relationship between ethnicity and MA. Nevertheless, there is cause to believe that there may still be a significant relationship as the sample collected from this study only had 18 students who were categorised as Non-British. From other articles and studies we can confidently state that there must be some sort of association between ethnicity and mathematics as there is a vast amount of research showing that 'English-speaking countries, with the exception of Canada, there is widespread talk of a STEM 'crisis' and that countries in East and Southeast Asia which share a Post-Confucian heritage are exceptionally dynamic in STEM; China, South Korea, Japan, Taiwan and Singapore' (Marginson, Tytler, Freeman, & Roberts, 2013).

Furthermore, research on ethnic minorities in education and STEM subjects should be taken into consideration as this indicated that the gender gap present was not the only diversity gap present. It was found that there was a lack of racial diversity within STEM subjects and that Black and Minority Ethnic (BME) males were 28% less likely to work in STEM than White men (Campaign for Science and Engineering, 2014). Aforementioned, the UK is one of the most unequal societies of the world and this ethnic minority gap goes beyond STEM subjects. This is shown as the recorded number of Black students in full time HE in 2016/17 was 7% (Hesa.ac.uk, 2018).

4.3. Family influences

The psychologists who analyse family constellations talk about the importance of the number of siblings, age differences between them, order and sex as factors that intervene in the social development of the person. Some of the conclusions reached are that the firstborn children tend to have better academic and professional achievements, as well as better scores on intelligence tests (Hanushek, 1992). Hunushek (1992) found contradictory findings to our own that being early in the birth order implies a distinct advantage, entirely because of the higher probability of being in a small family. However, this study did not research MA levels and had this been researched, it could imply that if the oldest sibling had low MA levels this could influence their younger siblings as Bandura (2001) found that social learning and modeling of behavior is a key process by which older siblings influence their younger siblings. This influence can include positive behaviour on their academic studies hence, lower levels of MA if their older siblings had shown little resistance towards mathematics.

Moreover, parental support was a factor which was studied to determine whether students who had a positive home learning experience through their childhood had a lower MA score than those who did not have any/little support. Research on parents' daily involvement in their children's lives has found that adolescents whose parents show higher levels of involvement, both in general and specifically tailored to the school context, tend to have higher grades and academic self-perceptions (Furstenberg, Cook,, Eccles, Elder, & Sameroff, 1999; Juang & Silbereisen, 2002). Melhuish, Sylva, Sammons, Siraj-Blatchford, & Taggart (2001) concluded that, 'higher home learning environment was associated with increased levels of cooperation and conformity, peer sociability and confidence, lower anti-social and worried or upset behaviour and higher cognitive development scores … after age it was the variable with the strongest effect on cognitive development' (p.ii). Nevertheless, the levels of home learning experience will alter from family to family and is most commonly linked to social-class. For decades it has been identified that those from working class backgrounds tend to have a more chaotic upbringing, including; less social support and resources (Thompson, 2017). This is another factor which could have been investigated as the results may have been influenced due to the fact that the majority of students in the UK have a middle-upper class background. Statistics by the BBC News (2018) report that Black students make up 8% of the UK university population and about 4% of 18-24-year-olds in England and Wales.

5. CONCLUSION AND FURTHER WORK

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 parent ethnicity*parent support gender. Students from a British background received support predominantly from a male family figure. This might be one of the reasons of the gender unbalance on 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 of undergraduate students pursuing a STEM degree**.**

Further research on this study includes the exploration of why having a greater number of siblings decreases MA levels as this was not an expected to be a significant factor. It would also be beneficial to identify whether they are the older, younger or middle sibling, whether they are a twin and the gender of their other siblings. Moreover, the same study could be

conducted but also include other universities within the UK instead of basing it upon one institution. This could even be developed further with a key focus on ethnicity and conduct this experiment with international universities and compare the results with universities from the UK.

Finally, MA 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.

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