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Psychological barriers in maths education: Insights from Iran, Pakistan, and Uganda



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Introduction

Programme for International Student Assessment (PISA) 2018 data based on around 600,000 students across 79 countries, showed that one in four 15-year-olds did not attain a minimum level of proficiency in reading or mathematics (maths). Further to this, in 24 countries, more than 50% of students failed to achieve Level 2 maths, which means a large number of students have difficulty interpreting and recognising how a (simple) situation can be represented mathematically (Organisation for Economic Co-operation and Development [OECD], 2019). This highlights the need to increase efforts to improve maths education globally, with a specific emphasis on the United Nations Sustainable Development Goal (UN SDG) four: *Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*.

Strong, functional maths skills are not only essential for everyday functioning. Poor maths skills have been associated with unemployment and low wages, poor physical and mental health, and increased risk of incarceration (Gross et al., 2009). There is also a clear link between maths attainment and economic development, with many low achieving students residing in developing nations or countries with a low income per capita (United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2017). PISA 2018 showed maths attainment to be the lowest in countries in the global south (OECD, 2020), including countries eligible to receive official development assistance (ODA), e.g., Indonesia, Columbia, Cuba, Costa Rica, and Brazil. Despite this, the majority of research that has been conducted to address low attainment levels and barriers to maths learning has been carried out in Europe and North America (Hunt et al., 2021). An interdisciplinary and globally collaborative approach is likely to be the most effective strategy in fully understanding barriers to maths education, including partnerships between academics across ODA-recipient and non-ODA-recipient countries (Hunt et al., 2021).

Maths anxiety

Children are not born fearful of maths. Instead, many factors facilitate the development of maths anxiety (Luttenberger et al., 2018). Defined as feeling anxious, apprehensive and tense while dealing with mathematical problems or manipulating numbers, maths anxiety is common in educational settings. While solving maths problems, maths anxiety affects individuals by interfering with their cognitive processes, such as working memory, which consequently decreases their maths performance (Ashcraft & Krause, 2007). It can also disrupt affective mechanisms, reported as increased heart rate, perspiration, shaking, and nausea, which negatively affects maths performance (Brewster & Miller, 2020; Foley et al., 2017). Moreover, robust and consistent empirical evidence further supports a negative correlation between maths anxiety and maths performance. However, PISA 2012 data also indicate many high maths performing students from East Asian countries report high maths anxiety. Thus, a range of possible influences should be considered, including culture, societal

pressure, and parental, teacher and peer anxiety (Brewster & Miller, 2020; Foley et al., 2017). The PISA 2018 data also demonstrated a general trend, whereby females reported higher maths anxiety and lower maths performance than their male counterparts (OECD, 2021). It is possible that societal gender stereotypes contribute to female students' underperformance, which not only increases their maths anxiety but discourages women from studying maths (Luttenberger, et al., 2018; Tomasetto, 2019). This in turn may act as a barrier to pursuing a profession in Science, Technology, Engineering and Mathematics (STEM), which has a growing demand worldwide (Foley et al., 2017).

Maths attitudes

Substantial empirical evidence shows the effect of maths anxiety on the learner's behaviours, thinking and emotional responses, which influence their overall maths attitudes (Primi et al., 2020). Learners with high maths anxiety may show adverse learning behaviours, such as avoiding doing maths work or devoting less study time to learning maths. Luttenberger and colleagues (2018) suggested that higher maths anxiety is associated with procrastination and postponement of homework and preparation for exams, in addition to less concentration or limited attention in maths learning sessions, ultimately contributing to overall poorer maths performance. Moreover, being fearful of maths and demonstrating unhelpful behaviours may not only lead to poor performance but are also associated with attitudes and beliefs, including lower maths self-efficacy.

Maths enjoyment

A somewhat encouraging finding has been the positive relationship between maths enjoyment and maths performance (Pekrun et al., 2017), with this relationship having been shown to be reciprocal, i.e. maths enjoyment is associated with improvements in performance and improved performance is associated with increased maths enjoyment. However, some research has suggested that, as students' age increases, their level of maths enjoyment declines (Mata et al., 2021; Mata et al., 2017).

Maths shame

The feeling of shame associated with maths has been a relatively unexplored emotion when compared to that of maths anxiety. Feelings of shame and humiliation towards maths have been investigated from an educational standpoint, however authors have largely focused on the experiences of teachers rather than students (Bibby, 2002; Wilson, 2017). The way in which shame is depicted as being a social emotion, and the emphasis of links with both self-doubt and self-worth, are likely applicable to the experience of a student (Bibby, 2002). Indeed, self-worth has previously been linked with both maths performance and responding more positively to failure (Thompson et al., , 2007). More recent research, however, has somewhat contradicted this, by demonstrating that a group of individuals categorised by higher levels of shame towards maths actually performed better at maths than the other

groups in the study (Ganotice et al., 2016). The link between collectivism and shame was provided as a possible explanation for this alongside the explanation that shame may lead to individuals working harder to actively avoid shame. While somewhat contradictory, these studies highlight the importance of studying the effects of more complex emotions, such as shame, in relation to maths.

Mathematical resilience

Mathematical resilience has been defined as a learner's capacity to continue learning maths despite facing setbacks and challenges (Johnston-Wilder & Lee, 2010). A learner who displays stronger mathematical resilience tends to have a set of personal skills and characteristics that help them to adapt and positively cope with challenges. Mathematical resilience can also be considered in relation to the confidence to transfer mathematical knowledge to other people and situations. Mathematical resilience helps students to realise their potential, such as being aware of their strengths and limitations, leading them to progress their mathematical thinking, skills, knowledge, and strategies to learn and excel in maths. Trends in International Mathematics and Science (TIMSS) data, obtained from several countries, revealed that Asian students who spent more time doing maths homework showed positive maths attitudes and high mathematical resilience (Sandoval-Hernández & Białowolski, 2016). Similarly, PISA 2012 data from over 50 countries showed that students with high mathematical resilience, academic motivation and self-esteem performed better in maths (OECD, 2021). The studies also demonstrated a negative correlation between mathematical resilience and maths performance. However, Johnston-Wilder and Lee (2020) propose that students low in mathematical resilience can excel in maths by overcoming their maths anxiety with the help of teachers and resources that can empower them. Therefore, those who learn to strengthen their ability to manage their emotions and cope with threatening and challenging situations can enhance their mathematical resilience. Consequently, it is important to further explore mathematical resilience along with maths anxiety among students, alongside other variables to further our understanding of psychological barriers to maths learning and how to support students accordingly.

Subdivisions of mathematical resilience

According to Kookan et al. (2015), there are three factors that comprise their Mathematical Resilience Scale. These include a growth mindset, maths struggle and maths value. A growth mindset is where individuals believe their ability is amenable and open to change (Yeager & Dweck, 2012). This has been shown to have a striking effect on performance, with a recent study showing that an increase in growth mindset can reverse observed gender differences in maths performance, such that women who were high in growth mindset were able to outperform both males and females who were low in growth mindset (Degol et al., 2018). Maths value relates to how valuable individuals believe maths to be; this is important as other work has shown beliefs such as "maths is useless" is a reason why 16-year-olds did not pursue

further maths education (Brown et al., 2008). Maths struggle has been studied much less, but is a construct relating to the belief that all individuals struggle with maths, regardless of their profession or intelligence (Xolocotzin, 2017).

Academic motivation

In educational settings, student motivation, which is defined as the real reasons, purpose, goals or beliefs to study or acquire skills, is significantly associated with student performance or academic achievement (Mercier & Sperber, 2017). Students can be motivated to learn for extrinsic rewards, such as for a better career or job in the future, money, parental or peer appraisal, or meeting family expectations. Students can also be intrinsically motivated to learn, e.g. for enjoyment or personal fulfilment (Michaelides et al., 2019). PISA (2012) showed that students with high maths performance reported high extrinsic motivation to study maths so they could get better jobs in the future (OECD, 2021). In contrast, students with high intrinsic motivation and moderate maths anxiety had overall high maths performance, demonstrating the way in which variables such as these combine to predict performance (Luttenberger et al., 2018). Moreover, Li and colleagues (2021) discussed in their review that the majority of empirical studies have revealed intrinsic motivation to be a strong predictor of maths achievement in 59 societies. However, it is important to note that the majority of studies were conducted in western countries in which an individualistic culture dominates. In contrast, students from collectivistic societies and with high extrinsic motivation were likely to perform better to gain parental, family or external appreciation. There may be various factors that influence the relationship between motivation and maths attainment, such as culture, socioeconomic conditions, individual differences, such as gender, and psychological factors, such as maths anxiety.

Cultural values

One plausible explanation for the differences in maths achievement reported by PISA (2018) is the national culture or the way people live within a country. An individualistic culture, which is predominant in North American and Western European countries, emphasizes an individual's uniqueness and needs where they have societal flexibility and are not enforced to conform to the norms. In contrast, collectivist societies such as in East Asian, Subcontinent, Middle Eastern and African countries, emphasize the person's identification as part of a group, such as caste, family or country, followed by expectations of certain duties and roles by the individual as a member of the group (Carducci, 2012). Despite the scarcity of empirical research, a recent study investigated data from 51 countries revealing that 23.89% of inter-country differences in maths performance were attributed to national culture (Hu et al., 2018). Furthermore, a strong positive correlation between maths achievement and long-term orientation was found, which is a dominant cultural value in East Asian countries with collectivist cultures, such as South Korea, Japan, Taiwan and China.

Parental influence

Along with maths anxiety and maths attitudes, considerable research interest has been seen in determining the role of environmental factors, such as parental influence, on children's maths achievement. Rubinsten and colleagues (2018) have also highlighted that parental influence may mediate the development of maths anxiety and have a significant impact on children's performance. These include parental fears or feelings of being insecure about maths, contributing to negative bias in children and the development of preconceived ideas of maths being a difficult subject. Studies have also found that deficiency in numerical skills or lack of mathematical knowledge and confidence in parents may also predict greater maths anxiety and low maths performance in their children. It is possible that the extent to which parents help and support their children in learning maths varies according to the parent's level of education. Furthermore, empirical evidence also shows that parental pressures and practices influence the development of maths anxiety and their child's performance (Sari & Hunt, 2020). These might include parental involvement in children's maths learning, such as monitoring and regulating maths homework and preparation for tests. Another contributing factor is high or unrealistic parental expectations of their children's maths abilities or attainment, which may influence feelings of maths anxiety and fear of failure. More work is needed to investigate the possible link between children's maths attitudes, anxiety and performance, and cultural differences in parental attitudes and involvement in children's maths learning.

Iran

One of the semi-developed nations in Western Asia, 24.64% of Iran's population is under 14 years of age. Iran requires adequate reforms to provide educational support (World Bank, 2019). Despite no representation in PISA studies, empirical findings on Irani students have revealed a significant negative correlation between maths anxiety and academic achievement (Vakili & Pourrazavy, 2017). Moreover, self-efficacy has been found to be a strong predictor of test anxiety and maths performance in this largely collectivistic society (Arji et al., 2016). In addition, significant gender differences have been reported in adolescents for maths anxiety and performance, with female students performing worse and reporting higher maths anxiety (Abbasi et al., 2013). Recently, Asanjarani and Zarebahrabadi (2021) assessed the effectiveness of intervention techniques focusing on cognitive beliefs and physiological symptoms in Irani students (mean age = 11 years) with high maths anxiety and low maths self-concept. They found the intervention led to a reduction in maths anxiety and an increase in maths self-concept.

Pakistan

A developing country in South Asia with 24.3% of its population living under the poverty line, the low-income nation requires immediate educational reforms to support the 35.4% of its population that lie within 14 years of age, including 11.4 million Pakistani adolescents who do

not receive formal education (United Nations Children's Emergency Fund [UNICEF], 2017; World Bank, 2020). Despite not being represented in PISA studies, empirical findings based on Pakistani adolescents show a strong correlation between intrinsic motivation and maths achievement within the largely collectivistic society (Hussain et al., 2020). These findings were also supported by Joseph and Rodrigues (2021) who reported that male students had greater self-efficacy, which predicted lower maths anxiety. However, a survey that explored maths anxiety and performance among secondary school students did not find significant sex differences (Batoool et al., 2020) despite a well-known significant gender disparity within Pakistani society, barring access to education for girls through sociocultural and religious pressures.

Uganda

There is no doubt about the scarcity of empirical research on the rapidly growing population of Uganda, which has 46.5% of its population within 14 years of age. There is a strong need to study the student population of the developing East African nation, which requires utmost educational support to decrease poverty risk and improve economic conditions. A study on adolescents revealed that maths self-efficacy and enjoyment strongly predicted motivation to pursue maths in higher education and as a career (Muwonge et al., 2018). Moreover, another study found moderate sex differences in maths performance of adolescents, which were mediated by the perception of gender stereotypic expectancies (Picho & Schmader, 2018). The findings indicate the existence of gender inequality in maths education, which is influenced by sociocultural stereotypes that discourage girls when it comes to maths education and jobs.

Method

Design

A cross-sectional survey design was utilised. Questions focused on maths performance, maths anxiety, maths enjoyment, maths shame, mathematical resilience (growth mindset, maths struggle, maths value), intrinsic and extrinsic motivation, collectivism, and peer and parental influence. In addition to these psychological variables the demographic variables of gender, parents' education, hours of study, and the presence of a tutor, were also investigated.

Sample

The sample in each given country consisted of students aged between 14 and 16 years old, with participants being sampled from one mixed gender school in Uganda, another mixed gender school in Pakistan, and a female-only school in Iran. The demographic information for the sample from each country can be found below.

Uganda

A sample of 356 students were recruited in Uganda via a paper-based survey. Nine students had a substantial amount of missing data, leaving a sample of 347 (97.47%). The participants were fairly evenly split based on gender, with 46.6% being male, 51.7% being female, 0.8% reporting as other, 0.3% preferring not to say, and 0.6% not reporting gender.

Pakistan

A sample of 441 students were recruited in Pakistan via an online survey. However, due to substantial amounts of missing data, data from 154 participants were removed, leaving a sample of 287 (65.08%). There was a fairly even split based on gender, with 46% of participants being male, 53.6% being female, 0.7% self-identifying, and 0.7% preferring not to say.

Iran

A sample of 249 students were recruited from Iran via an online survey. However, due to a substantial amount of missing data, data from 8 participants were removed from the analyses, leaving 241 (96.79%).

Materials

Maths performance was measured via a single self-report question, where participants were asked what grade they got on their last maths test. In Uganda this was scored on a scale of 1 to 9, in Pakistan this was scored from E – A*, and in Iran this was measured on a scale of 0 to 20.

Maths anxiety, maths enjoyment, and maths shame (associated with one's perceived maths ability and performance) were measured using the modified version of the Achievement Emotions Questionnaire (Pekrun et al., 2011). This modified scale consisted of 33 statements measured on a Likert scale from 1 to 5, with 1 being "strongly disagree" and 5 being "strongly agree". According to Pekrun et al. (2011) the AEQ has a good level of internal consistency.

Mathematical resilience, comprising growth mindset, maths struggle, and maths value, was measured using the Mathematical Resilience Scale (Kooken et al., 2016). This version included 21 of the 24 statements included in the initial scale, with these being measured on a Likert scale from 1 to 7, with 1 being "strongly agree" and 7 being "strongly disagree". Each of the 3 subscales were shown to have good to excellent levels of internal consistency (Kooken et al., 2016).

Academic motivation, comprising intrinsic motivation and extrinsic motivation, was measured using the high school version of the Academic Motivation Scale (Stover et al., 2012; Vallerand et al., 1992). This scale consisted of 28 statements measured on a scale of 1 to 7, with 1 being "does not correspond at all" and 7 being "corresponds exactly". Internal consistency was shown to be good (Stover et al., 2012).

Peer influence (3 items) and parental influence (3 items) were measured using the corresponding items used in the 2012 Program for International Student Assessment (PISA) Questionnaire. These questions were measured on a scale of 1 to 4, with 1 being “strongly agree” and 4 being “strongly disagree”.

Collectivism was measured by averaging participants' scores on the 6 items relating to collectivism that were extracted from the Cultural Values Scale CVSCALE (Yoo et al, 2011). Statements were scored on a scale of 1 to 7, with 1 being “strongly disagree” and 7 being “strongly agree”. The internal consistency of this scale was shown to be very good, with Cronbach’s alphas between .85 and .89 (Yoo et al., 2011).

Participants were asked to provide their gender and their mother’s and father’s level of education (ranging on a scale from 0, no education, to 8, doctoral level education). Participants were also asked how long they studied maths outside of school each week; while the inputs for this variable were unrestricted, only reports of less than 21 hours were considered, as any number above this would have been both unfeasible and unrealistic. Presence of tutor was also ascertained by asking participants if they had a maths tutor outside of school, with the binary answers of yes or no.

Procedure

Ethical approval from the relevant ethics committees in each country was obtained prior to any data collection. Informed consent was first gained from the students and data collection took place during school time. The students were asked to complete the survey in silence and not to communicate or share answers with one another. In Uganda, the survey was presented on paper, in Pakistan it was presented via the online survey software Qualtrics, and in Iran it was presented using the online survey building website Porsline. Data were collected and stored in accordance with the General Data Protection Regulation.

Analytic strategy

First, a series of one-way ANOVAs were conducted on each variable, except for maths performance, to investigate whether there were any inter-country differences in both the psychological and non-psychological variables. Then, a series of bivariate correlations were conducted on these variables within each country, this time including maths performance. Hierarchical regressions were then conducted for each country, with the non-psychological variables being entered first, followed by the psychological variables. A total of four multiple regressions were conducted per country, predicting maths performance, maths anxiety, maths enjoyment and maths shame.

Results

First, one-way between groups ANOVAs were conducted on the data between Uganda, Pakistan and Iran concerning the variables of: mother's education, father's education, hours of study, mathematical resilience, extrinsic motivation, intrinsic motivation, peer influence, parental influence, collectivism, maths enjoyment, maths anxiety, maths shame, growth mindset, maths struggle, and maths value. A summary of the means, standard deviations, effect sizes, and statistical significance can be found in Table 1. The results of follow-up comparisons, using Bonferroni tests, can be found in Table 2.



Table 1. The means and standard deviations for each variable split by country, and the overall effect size and statistical significance of the one-way ANOVA.

Dependent Variable	Eta-squared	Mean (SD)		
		Uganda	Pakistan	Iran
Mother's education**	.016	3.81(2.35)	4.45(2.29)	3.97(1.55)
Father's education***	.069	4.08(2.56)	5.3(2.07)	4.05(1.42)
Hours of study	.006	3.46(3.60)	4.02(3.50)	3.55(2.34)
Maths resilience***	.290	5.56(.55)	4.59(.60)	5.20(.81)
Extrinsic motivation***	.329	5.96(.86)	4.26(1.37)	5.78(1.03)
Intrinsic motivation***	.248	5.03(1.03)	4.13(1.27)	5.77(1.02)
Peer influence***	.140	3.22(.77)	2.88(.76)	2.50(.60)
Parental influence***	.420	3.74(.62)	2.90(.81)	2.22(.76)
Collectivism***	.085	4.76(1.43)	3.79(1.38)	4.40(1.24)
Maths enjoyment***	.178	4.04(.82)	3.14(.86)	3.59(.79)
Maths anxiety***	.033	2.49(.90)	2.83(.84)	2.82(.90)
Maths shame***	.044	2.54(.90)	2.66(.85)	2.18(.93)
Growth mindset***	.248	5.18(.98)	3.78(1.05)	4.76(1.13)
Maths struggle***	.091	5.13(1.04)	5.19(1.00)	5.82(.74)
Maths value***	.254	6.16(.76)	4.82(1.17)	5.09(1.19)

*** $p < .05$, ** $p < .01$, *** $p < .001$**

Table 2. The mean differences and significance for each variable derived from a post-hoc Bonferroni analysis.

Dependent Variable	Uganda		Pakistan
	Compared with Pakistan	Compared with Iran	Compared with Iran
Mother's education	-.63**	-.15	.48*
Father's education	-1.22***	-.03	1.25***
Hours of study	-.56	-.09	.47
Maths resilience	.97***	.35***	-.62***
Extrinsic motivation	1.69***	.17	-1.52***
Intrinsic motivation	.89***	-.74***	-1.64***
Peer influence	.34***	.72***	-.38*
Parental influence	.84***	1.53***	-.68***
Collectivism	.98***	.36**	-.62***
Maths enjoyment	.90***	.45***	-.45***
Maths anxiety	-.33***	-.33***	.01
Maths shame	-.12	.36***	.48***
Growth mindset	1.40***	.42***	-.98***
Maths struggle	-.07	-.70***	-.63***
Maths value	1.33***	1.07***	-.27**

*** $p < .05$, ** $p < .01$, *** $p < .001$**

While it was clear from the results above that there were differences between the three countries on the majority of the variables that were investigated, it was also important to consider how these variables related to each other in each of the countries investigated. For this purpose, Pearson's correlations were conducted between all of the above listed variables except for negative emotion towards maths and mathematical resilience, as the subscales of both of these variables were deemed to be more informative than the total

scores. The correlation coefficients and significance levels are reported for Uganda, Pakistan, and Iran, respectively in tables 3, 4 and 5.

Table 3. Correlation coefficients and significance of the Pearson's correlations between each of the considered variables in Uganda.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
[1] Maths performance	1														
[2] Growth	.26** *	1													
[3] Struggle	.02	-.01	1												
[4] Value	.13*	.16**	.06	1											
[5] Enjoyment	.45** *	.24** *	-.03	.35** *	1										
[6] Maths anxiety	- .52** *	- .23** *	.18** *	- .34** *	- .69** *	1									
[7] Maths shame	- .43** *	- .22** *	.10	- .28** *	- .55** *	.76** *	1								
[8] Extrinsic motivation	.09	.10	.12*	.34** *	.17** *	-.10	-.03	1							
[9] Intrinsic motivation	.09	.03	.09	.29** *	.21** *	-.09	-.04	.73** *	1						
[10] Peer influence	.17**	.18**	.00	.20** *	.30** *	- .22** *	- .16* *	.10	.08	1					
[11] Parental influence	.05	.11*	.07	.18**	.16**	-.13*	-.11*	.15**	.11*	.34** *	1				
[12] Collectivism	.03	.04	-.02	.06	.10	-.07	-.07	.13*	.15* *	-.08	.03	1			
[13] Mother's education	.13*	-.05	.03	.02	.07	-.05	-.11*	.03	.04	.00	-.05	.03	1		
[14] Father's education	.17**	-.01	-.01	-.04	.08	.02	.01	-.02	-.01	-.01	-.03	.02	.50** *	1	
[15] Hours studied outside classroom	.05	.06	- .15**	-.03	.10	- .18**	-.13*	-.01	.01	-.07	-.03	-.02	.09	.14* *	1

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 4. Correlation coefficients and significance of the Pearson's correlations between each of the considered variables in Pakistan.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
[1] Maths performance	1														
[2] Growth	.14*	1													
[3] Struggle	.01	-.36** *	1												
[4] Value	.10	-.34** *	.50** *	1											
[5] Enjoyment	.32** *	.26** *	-.07	.07	1										
[6] Maths anxiety	-.20** *	.01	-.20** *	-.30** *	-.02	1									
[7] Maths shame	-.14*	-.04	-.20** *	-.27** *	.01	.87** *	1								
[8] Extrinsic motivation	.25** *	.41** *	-.05	-.11	.44** *	.09	.03	1							
[9] Intrinsic motivation	.27** *	.37** *	-.13*	-.07	.51** *	.02	-.01	.80** *	1						
[10] Peer influence	.00	-.20** *	.27** *	.32** *	-.01	-.18**	-.19**	-.09	-.04	1					
[11] Parental influence	.04	-.21** *	.40** *	.42** *	.03	-.21** *	-.21***	.03	.02	-.42** *	1				
[12] Collectivism	.20** *	.20** *	-.06	-.11	.49** *	.21** *	.16** *	.53** *	.52** *	.10	-.04	1			
[13] Mother's education	.16*	.18**	-.04	-.16*	.12	-.04	-.12	.20** *	.19** *	.09	-.10	.20** *	1		
[14] Father's education	.18**	.17**	-.13*	-.18**	.11	.03	.00	.22** *	.18**	.13*	-.03	.17**	.72***	1	
[15] Hours studied outside classroom	.19**	.10	-.10	-.04	.09	-.12*	-.09	.01	.09	.03	-.01	-.05	.20***	.06	1

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 5. Correlation coefficients and significance of the Pearson's correlations between each of the considered variables in Iran.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
[1] Maths performance	1														
[2] Growth	.23***	1													
[3] Struggle	.13*	.37***	1												
[4] Value	.08	.33***	.41***	1											
[5] Enjoyment	.44***	.47***	.28***	.56***	1										
[6] Maths anxiety	-.32***	-.42***	-.21***	-.31***	-.57***	1									
[7] Maths shame	-.28***	-.46***	-.25***	-.24***	-.49***	.81***	1								
[8] Extrinsic motivation	.12	.17**	.16*	.19**	.28***	.01	.00	1							
[9] Intrinsic motivation	.21***	.28***	.29***	.30***	.53***	-.20**	-.18**	.71***	1						
[10] Peer influence	.00	.00	-.04	-.09	-.08	.11	.10	.02	.05	1					
[11] Parental influence	-.13	-.21***	-.15*	-.47***	-.37***	.26***	.18**	-.09	-.14*	-.13*	1				
[12] Collectivism	.16*	.05	.02	.07	.08	.06	.04	.40***	.36***	-.03	-.02	1			
[13] Mother's education	.24***	.29***	.07	.09	.23***	-.33***	-.28***	-.04	.06	.09	.24***	-.05	1		
[14] Father's education	.28***	.21***	-.01	.07	.21***	-.19**	-.19**	-.01	.08	.03	.23***	.01	.64***	1	
[15] Hours studied outside school	.18**	.24***	.12	.25***	.27***	-.31***	-.28***	-.06	.07	.10	.20***	-.13*	.14*	.14*	1

* $p < .05$, ** $p < .01$, *** $p < .001$

It was clear from these correlations that maths performance was correlated with multiple variables in each of the three countries; however, this only considered the effect of these variables in isolation. This was insufficient to ascertain the relation that the variables had with maths performance, because the correlations did not consider the underlying relation between all the variables in question. Thus, a multiple regression was needed, with this taking the form of a hierarchical regression separating the variables into psychological and non-psychological variables. The non-psychological variables of mother's education, father's education, hours of study, presence of a tutor, and gender (except in Iran) were entered into the models first, followed by the psychological variables of extrinsic motivation, intrinsic motivation, peer influence, parental influence, collectivism, maths enjoyment, maths anxiety, maths shame, growth mindset towards maths, maths struggle, and maths value. Therefore, hierarchical models were constructed to investigate how these variables significantly predicted maths performance. The R-squared and R-squared change of the overall models, and the standardised betas for each individual variable are reported for Uganda, Pakistan and Iran in Table 6.



Table 6. The hierarchical models predicting maths performance in Uganda, Pakistan and Iran, including the R-squared and R-squared change of the overall models, and the standardised betas for each individual variable.

		Uganda			Pakistan			Iran		
Step	Variables Entered	Beta	R ² Change	Model R ²	Beta	R ² Change	Model R ²	Beta	R ² Change	Model R ²
1	Gender	-.162**		.051*	.061		.067*	N/A		.104***
	Mother's education	.056			.031			.091		
	Father's education	.069			.131			.194*		
	Hours of study	.021			.185**			.144*		
	Presence of a tutor	-.096			.064			-.037		
2	Gender	-.059	.345***	.395***	.040	.153***	.220***		.196***	.300***
	Mother's education	.038			-.047			.019		
	Father's education	.097			.175			.170*		
	Hours of study	-.063			.174**			.095		
	Presence of a tutor	-.060			.056			-.047		
	Maths enjoyment	.102			.133			.498***		
	Maths anxiety	-.436***			-.355**			-.099		
	Maths shame	-.044			.161			.026		
	Growth mindset	.191***			-.013			-.038		
	Maths struggle	.103			-.041			.114		
	Maths value	-.085			.170*			-.245**		
	Extrinsic motivation	.027			.158			.059		
	Intrinsic motivation	.022			-.033			-.122		
	Peer influence	.045			-.031			.041		
	Parental influence	.005			-.082			.015		
	Collectivism	.004			.113			.137*		

* $p < .05$, ** $p < .01$, *** $p < .001$

Prior to the inclusion of the psychological variables there were differences in maths performance according to gender in Uganda, with males scoring higher than females. However, after the inclusion of the psychological variables this effect was no longer shown. Only two demographic variables remained significant after the addition of the psychological variables, with these being hours of study in Pakistan and father's education in Iran. The largest predictor of maths performance in both Uganda and Pakistan was maths anxiety, however in Iran it was maths enjoyment, with maths anxiety not even reaching significance. A growth mindset towards maths significantly predicted higher maths performance in Uganda, whereas maths value significantly predicted greater maths performance in both Pakistan and Iran.

It was clear from these hierarchical regressions that maths anxiety was the largest predictor of maths performance in Uganda and Pakistan, and that maths enjoyment was the largest predictor of maths performance in Iran. Therefore, it was important to investigate what variables were able to predict these psychological variables. Predictors of maths shame were also investigated, as while this variable was not shown to significantly predict maths performance, it was shown to have significant bivariate correlations with many of the variables under investigation. Hierarchical models were constructed once again, this time entering the non-psychological variables of mother's education, father's education, hours of study, presence of a tutor, and gender (except in Iran) into the models first, then entering the psychological variables of extrinsic motivation, intrinsic motivation, peer influence, parental influence, collectivism, maths enjoyment, maths anxiety, and maths shame. The R-squared and R-squared change of the overall models, and the standardised betas for each individual variable for Uganda, Pakistan and Iran are reported for outcome measures of maths anxiety (Table 7), maths enjoyment (Table 8), and maths shame (Table 9).



Table 7. The hierarchical models predicting maths anxiety in Uganda, Pakistan and Iran, the R-squared and R-squared change of the overall models, and the standardised betas for each individual variable.

		Uganda			Pakistan			Iran		
Step	Variables Entered	Beta	R ² Change	Model R ²	Beta	R ² Change	Model R ²	Beta	R ² Change	Model R ²
1	Gender	.235***		.098***	-.038		.023	N/A		.184***
	Mother's education	-.049			-.048			-.339***		
	Father's education	.075			.025			.067		
	Hours of study	-.150*			-.129			-.273***		
	Presence of a tutor	.122*			-.046			-.034		
2	Gender	.199***	.171***	.268***	-.028	.164***	.188***	N/A	.136***	.321***
	Mother's education	-.067			-.042			-.229**		
	Father's education	.088			.007			.080		
	Hours of study	-.113*			-.085			-.151*		
	Presence of a tutor	.086			-.019			.002		
	Growth mindset	-.122*			-.233**			-.268***		
	Maths struggle	.178**			-.023			.012		
	Maths value	-.281***			-.234***			-.108		
	Extrinsic motivation	.024			.045			.207*		
	Intrinsic motivation	-.073			-.223*			-.219*		
	Peer influence	-.075			.013			.054		
	Parental influence	-.069			-.101			.065		
	Collectivism	-.011			.265***			.026		

* $p < .05$, ** $p < .01$, *** $p < .001$

As shown above, there was a gender difference in maths anxiety in Uganda, with females reporting higher maths anxiety than males. After the inclusion of the psychological variables, hours of study significantly predicted lower maths anxiety in both Uganda and Iran, with mothers' education also significantly predicting lower maths anxiety in Iran. A growth mindset towards maths significantly predicted lower maths anxiety in all three countries, with this also being shown for maths value, except in Iran. Intrinsic motivation significantly predicted lower maths anxiety in both Pakistan and Iran, although this was not shown in Uganda. Maths struggle significantly predicted higher maths anxiety in Uganda, extrinsic motivation significantly predicted higher maths anxiety in Iran, and collectivism significantly predicted higher maths anxiety in Pakistan.



Table 8. The hierarchical models predicting maths enjoyment in Uganda, Pakistan and Iran, the R-squared and R-squared change of the overall models, and the standardised betas for each individual variable.

		Uganda			Pakistan			Iran		
Step	Variables Entered	Beta	R ² Change	Model R ²	Beta	R ² Change	Model R ²	Beta	R ² Change	Model R ²
1	Gender	-.063		.055*	.036		.026	N/A		.114***
	Mothers education	-.020			.116			.159		
	Fathers education	.071			.018			.074		
	Hours of study	.085			.063			.232**		
	Presence of a tutor	-.199***			.051			.028		
2	Gender	-.050	.216***	.270***	<.001	.280***	.306***	N/A	.440***	.554***
	Mothers education	.002			.003			.060		
	Fathers education	.044			.023			.028		
	Hours of study	.061			.078			.061		
	Presence of a tutor	-.182***			-.024			-.007		
	Growth mindset	.153**			.109			.228**		
	Maths struggle	-.025			-.024			-.085		
	Maths value	.242***			.231**			.342**		
	Extrinsic motivation	-.068			-.086			-.148*		
	Intrinsic motivation	.156			.276**			.470**		
	Peer influence	.162**			.007			.006		
	Parental influence	.100			.019			.093		
	Collectivism	.055			.328***			-.004		

* $p < .05$, ** $p < .01$, *** $p < .001$

Presence of a tutor was the only significant demographic predictor of maths enjoyment, with this significantly predicting lower maths enjoyment in Uganda. Maths value positively predicted maths enjoyment in all three countries, whereas a growth mindset towards maths only significantly predicted this in Uganda and Iran. Intrinsic motivation significantly predicted higher maths enjoyment in both Pakistan and Iran, but this was not significant in Uganda. In addition, extrinsic motivation significantly predicted lower maths enjoyment in Iran, peer influence significantly predicted higher maths enjoyment in Uganda, and collectivism significantly predicted higher maths enjoyment in Pakistan.



Table 9. The hierarchical models predicting maths shame in Uganda, Pakistan and Iran, the R-squared and R-squared change of the overall models, and the standardised betas for each individual variable.

		Uganda			Pakistan			Iran		
Step	Variables Entered	Beta	R ² Change	Model R ²	Beta	R ² Change	Model R ²	Beta	R ² Change	Model R ²
1	Gender	.145*		.059**	-.001		.038	N/A		.135***
	Mothers education	-.136			-.169			-.246**		
	Fathers education	.073			.078			-.001		
	Hours of study	-.111			-.073			-.242***		
	Presence of a tutor	.103			-.120			-.036		
2	Gender	.117	.125***	.184***	.009	.137***	.175***	N/A	.157***	.292***
	Mothers education	-.149*			-.150			-.121		
	Fathers education	.080			.056			-.001		
	Hours of study	-.093			-.039			-.128*		
	Presence of a tutor	.077			-.089			-.002		
	Growth mindset	-.145**			-.247***			-.348***		
	Maths struggle	.103			-.039			-.055		
	Maths value	-.276***			-.205**			-.025		
	Extrinsic motivation	.137			.011			.183*		
	Intrinsic motivation	-.051			-.159			-.178*		
	Peer influence	-.014			-.021			.062		
	Parental influence	-.054			-.095			.016		
	Collectivism	-.060			.208**			.015		

* $p < .05$, ** $p < .01$, *** $p < .001$

No demographic variable significantly predicted maths shame in either of the three countries. However, a growth mindset towards maths was shown to significantly predict lower maths shame in Uganda, but increased maths shame in Pakistan and Iran. Maths value significantly predicted lower shame in both Uganda and Pakistan, but not in Iran. Collectivism also significantly predicted greater maths shame in Pakistan.

Key Findings

- All of the variables studied significantly differed between the three countries, except for the number of hours the students studied maths each week, with students on average studying 3.67 (SD 3.25) hours a week.
- Bivariate correlations showed that maths anxiety was very strongly related to maths shame, across all three countries.
- The addition of psychological variables into the model predicting maths performance greatly raised the models' predictive ability in all three countries, with this being most notable in Uganda where the addition of the psychological variables raised this from 5.1% to 39.5% of the variance explained.
- The largest predictor of maths performance in both Uganda and Pakistan was maths anxiety. However, in Iran it was maths enjoyment; maths anxiety was not a significant independent predictor there.
- A growth mindset towards maths significantly predicted higher maths performance in Uganda, whereas maths value significantly predicted higher maths performance in both Pakistan and Iran.
- There was a significant difference in maths anxiety according to gender in Uganda, with females reporting higher levels of maths anxiety than males, however this was not the case in Pakistan.
- In Iran, the mother's education was a strong predictor of maths anxiety.
- A growth mindset towards maths generally predicted lower maths anxiety and shame, and greater maths enjoyment.
- Intrinsic motivation was a predictor of lower maths anxiety and higher maths enjoyment in both Pakistan and Iran.
- Collectivism significantly predicted higher maths anxiety, maths enjoyment and maths shame in Pakistan, but was shown to have no significant effects in Uganda and Iran.

Conclusion

The results of this report have highlighted the importance of considering psychological variables when investigating students' maths performance in low to middle income countries. The data from Uganda, Iran and Pakistan demonstrated this by showing that the addition of the psychological variables greatly improved the predictive ability of models predicting maths performance. In Uganda and Pakistan maths anxiety was shown to be negatively related to maths performance. This is consistent with previous research findings (Luttenberger et al., 2018) and demonstrates the importance of understanding and addressing maths anxiety, especially as maths anxiety is associated with other variables that influence maths performance (Brewster & Miller, 2020; Foley et al., 2017). The importance of the relationship between maths anxiety and maths performance in Uganda and Pakistan cannot be understated, as the size of the effect was greater than any other variable, including all of the demographic variables. In Iran, maths anxiety was not significantly related to maths performance, however maths enjoyment was shown to have a strong positive relationship with maths performance. The finding that positive emotions are important for success in maths has been demonstrated in other research, in a western sample (Pekrun et al., 2017).

The results also indicated that multiple variables contributed to self-reported maths anxiety, maths shame, and maths enjoyment. A growth mindset towards maths was associated with lower maths anxiety and maths shame, and was related to higher maths enjoyment. This is important given the observed relationship between maths anxiety and performance in Uganda and Pakistan, and the relationship between maths enjoyment and performance in Iran. In Pakistan and Iran, intrinsic motivation was related to lower maths anxiety and greater maths enjoyment. In Pakistan, collectivism predicted greater maths anxiety and maths enjoyment. As maths anxiety was related to maths performance in this sample, it is possible that collectivism may be indirectly related to maths performance, but this needs to be explored further. In Iran, the mother's level of education predicted lower maths anxiety; also something that warrants further study.

In Uganda, female students were shown to be higher in maths anxiety and to have lower maths performance, which is consistent with multiple previous studies conducted in other countries (Brewster & Miller, 2020; Foley et al., 2017). However, the gender difference in maths performance was reduced to non-significance when the psychological variables were entered into the model, further emphasising the influence of psychological variables on maths performance, specifically the role of maths anxiety. In Pakistan, however, neither of these differences were shown, as females and males did not significantly differ in either maths anxiety or maths performance. Despite the lack of observed gender differences in Pakistan, the gender differences in maths performance and maths anxiety in Uganda are worth highlighting.

In conclusion, understanding the role of the psychological variables that are related to maths performance may be vital for improving maths performance in developing countries. The role

of maths anxiety and enjoyment in particular are worth considering, as maths anxiety was a strong predictor of maths performance in Uganda and Pakistan, while maths enjoyment was the largest predictor of maths performance in Iran. The role of intrinsic motivation and a growth mindset towards maths are also worth considering as they were related to both maths anxiety and enjoyment.

Recommendations

It is recommended that greater consideration be given towards students' psychological profiles, especially in relation to their maths enjoyment and maths anxiety, including steps to reduce maths anxiety and increase maths enjoyment. There are multiple interventions that have been shown to have potential in reducing maths anxiety, including ones that are relatively easy and cheap to implement on a large scale. For example, Samuel and Warner (2021) demonstrated that the implementation of an intervention focused on mindfulness and growth mindset, which could largely be delivered via video, lowered maths anxiety. Similarly, Brunyé et al. (2013) demonstrated that a controlled breathing exercise could mitigate the effect that maths anxiety had on performance. A comprehensive review of interventions to lower maths anxiety can be found in Petronzi et al. (2021). There are also interventions that have been shown to increase maths enjoyment, e.g. Kaur and Prendergast (2021) demonstrated that an in-class writing intervention to support communication increased both students' self-confidence and enjoyment towards maths.

It is also recommended that both educators and officials implement ways to foster a growth mindset towards maths within students. In this project, growth mindset was shown to predict lower maths anxiety in Uganda and Pakistan, whilst also predicting greater maths enjoyment in Iran, with these being the largest predictors of maths performance in each country. As such, future interventions may benefit from focusing on fostering a growth mindset as a way to tackle negative affect towards maths, but possibly increasing maths performance indirectly. However, when considering which interventions to use to improve growth mindset, caution is advised, as large-scale interventions focusing on having students read about the malleability of intelligence and performance have shown to be inefficacious (Ganimian, 2020). More focused interventions, however, such as an hour-long video presentation teaching students how intellectual abilities can be developed, have been shown to have a noticeable effect on students' grades in general (Yeager et al., 2019). Thus it is recommended that growth mindset interventions be implemented, although care should be taken when deciding upon the depth and delivery of the information provided during these interventions.

In regards to gender differences in maths performance and anxiety, this study found mixed results in the two countries where gender comparisons were applicable. Indeed, in Uganda, gender differences were shown for both maths performance and anxiety, with females scoring lower on maths tests and higher in maths anxiety. Conversely, these differences were

not observed in Pakistan. In both countries maths anxiety was related to maths performance, with the results from Uganda even demonstrating that when psychological factors such as maths anxiety were considered, gender differences were reduced to non-significance. These results combined seem to indicate that while there has typically been a focus on gender differences in maths performance, gender differences in maths anxiety may be just as important. It should be noted, however, that only one school from each country was sampled; further work needs to be done to assess how generalisable the findings are. Despite this, if educators and policy makers are aiming to improve gender equality in maths performance, a focus on maths anxiety would likely be worthwhile and impactful.

Recommendation summary

- Greater consideration should be given to students' psychological profiles when educators and policy makers are aiming to improve maths performance.
- Targeted strategies to reduce maths anxiety may support improvements in maths performance.
- Targeted strategies to improve maths enjoyment may support improvements in maths performance.
- Educators should attempt to foster a growth mindset within their students, as this may decrease their maths anxiety and increase their maths enjoyment.
- A focus on reducing female students' maths anxiety may lead to more gender equal outcomes regarding maths performance.
- Each of the recommendations should be considered in light of the specific findings for each country.

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