



PARENT-CHILD MATHEMATICS AFFECT AS PREDICTORS OF CHILDREN'S MATHEMATICS ACHIEVEMENT

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Abstract

The current study investigated the relationship between children's and parents' self-reported maths affect and children's maths achievement. Participants comprised 186 child-parent dyads in Turkey. Findings showed that maths affect in children and their parents was unrelated. However, maths affect was a significant predictor of children's maths achievement. Importantly, this varied by grade. In grade three, child maths affect significantly predicted maths achievement, whereas parent maths affect was unrelated to achievement. Conversely, in grade four, the opposite pattern emerged; parent maths affect significantly predicted children's maths achievement, whereas child maths affect was unrelated to achievement. Furthermore, children's maths achievement significantly varied according to parents' level of education, whereby children whose parents were educated to undergraduate level considerably outperformed those whose parents were educated only to primary level. Parents with a lower educational status also reported significantly more difficulty in supporting their child's maths learning. These findings point towards the importance of parent maths affect, their level of education, and perceived difficulty in supporting children, as predictors of children's maths achievement. This is only the case in grade four, as maths becomes more challenging and there is a greater emphasis on competitive assessment. As such, the home numeracy environment and family maths tension should be addressed in preparation for children moving into grade four.

Keywords: Maths affect, mathematics achievement, parent, and primary school

INTRODUCTION

When findings from the data of countries with high success in international exams (TIMSS, PISA) are evaluated, it is clear that affective variables play an important role in influencing the success of students. There is now considerable empirical evidence that highlights the role of maths anxiety and maths attitudes as predictors of children's maths achievement. In particular, maths anxiety can be viewed as a negative emotional response to maths, often with debilitating and deleterious consequences. This can be considered in terms of in-the-moment mathematical problem solving, creating a sense of panic, helplessness, paralysis, and mental disorganization (Tobias & Weissbord, 1980), but also feelings in advance of doing maths, including dread or apprehension (Ashcraft & Faust, 1994).

Studies have consistently reported a negative correlation between maths anxiety and overall maths performance in children. In a meta-analysis in 1990, Hembree reported a correlation coefficient of $-.34$ among children in grades 5 to 12. In a more recent meta-analysis, Namkung, Peng, & Lin (2019) also observed an overall correlation of $-.34$ between maths anxiety and performance in school children, with correlations of $-.27$ and $-.36$ for primary and secondary school children respectively. A similar correlation of $-.27$ was reported in Ma's (1999) meta-analysis. According to Cohen's (1988) guidelines, these correlations represent a small-to-medium effect.

Rubinsten et al (2018) outline a number of risk factors associated with the development of maths anxiety. These include within-child predispositions, for example brain functioning, genetics, generalised anxiety, threat-related attentional bias, and poor past performance. However, they also



highlight environmental factors that purportedly act as mediators or moderators in the development of maths anxiety. For instance, parents may feel insecure about maths and may even have deficient numerical skills. Indeed, Srivastava, Imam and Singh (2016) demonstrated a significant negative association between Indian students' maths anxiety and their parents' level of education.

Parental pressure to maintain high achievements has been linked to an increase in children's maths anxiety (Daches Cohen & Rubinsten, 2017), as has parental involvement in the maths learning process (Roberts & Vukovic, 2011). Daches Cohen and Rubinsten (2017) found that mothers' self-reported maths skills were significantly negatively correlated with children's maths anxiety. They also found that children's maths fluency was poorer if their mother reported a greater degree of help with schoolwork and pressed for intellectual development. Whilst the authors suggest some of their findings may be explained by cultural differences in definitions of parental practice, e.g. what constitutes a low or high level of support or help with schoolwork, they conclude that the homework environment, particularly parenting involving more controlling aspects, is important in the context of children's maths learning and performance. Maloney, Ramirez, Gunderson, Levine and Beilock (2015) reported that maths anxiety in parents was only related to high maths anxiety in their children if the parents were actually involved in their children's maths homework. Casad, Hale and Wachs (2015) surveyed adolescents and parents in the US and found that parents' maths anxiety significantly negatively predicted adolescents' maths attitudes, maths self-efficacy and maths achievement. Furthermore, parent-child maths anxiety interacted to predict maths achievement, demonstrating the importance of better understanding maths learning in the home environment. Together, these findings seem to indicate the importance of parental involvement, combined with their maths attitudes, in predicting children's maths attitudes and maths achievement.

Gunderson, Ramirez, Levine and Beilock (2012) suggested further ways in which parents may influence children's attitudes towards maths. The first relates to the parent's expectations about their child's maths competence. Parsons, Adler and Kaczala (1982) provided evidence that this is the case, observing that parental expectations predicted children's maths self-concept and performance better than a child's previous maths performance. Of course, it is possible that parents simply have a more realistic view of their child's actual maths competency. However, it is also possible that expectancies in some way influence a child's maths attitudes and performance. Vukovic, Roberts and Green Wright (2013) measured parental involvement and children's maths anxiety and performance. They found evidence of mediation, whereby children's maths anxiety mediated the relationship between parental involvement and maths performance. That is, parental involvement, comprising home support and expectations, reduced the child's maths anxiety, which in turn improved their performance. However, this was only found to be the case for word problems and algebraic reasoning; no mediation was found for whole-number arithmetic. Secondly, Gunderson et al (2012) propose that parents may model particular maths attitudes, which transfer to their children. Whilst there is little research on this, the work of Else-Quest, Hyde, & Hejmadi (2008) provides some potential insight. In assessing behavioural expression of emotions among 165 mother-child dyads, the researchers observed significant positive correlations in the emotions expressed between mothers and their children during mathematical problem solving at home. Emotions included positive ones, such as joy, pride and humour, whereas negative emotions included frustration, sadness and contempt. The authors discuss these findings in relation to emotional contagion. That is, the way in which one person may mimic another's emotional expressions automatically and without conscious thought (Hatfield, Cacioppo, & Rapson, 1993). As Else-Quest, Hyde and Hejmadi (2008) point out, such correlations in expressed emotion may highlight the way in which parents can shape their child's emotions during homework interactions. It may also emphasise the need for parents to carefully monitor and regulate their own emotions; detailed analysis showed that mothers were more likely to display contempt during maths-learning interactions following their child's earlier poor performance.



Mathematics achievement and affect in Turkey

According to 2015 OECD data (OECD, 2019), Turkey was among the six least performing countries in mathematics (420 compared to a mean of 490 points). Turkey was also one of just three countries that saw a deterioration in maths performance among both low and higher performers 2012-2015, with lower socio-economic backgrounds associated with poorer maths performance (Ozdemir, 2016). The most recent OECD data indicates that maths attainment in Turkey remains significantly lower than the world average. Therefore, it is important to fully understand why Turkey consistently underperforms in mathematics compared to other countries. Given the substantial literature highlighting the role of maths attitudes and anxiety as barriers to maths education, it may be necessary to focus on cognitive-affective predictors.

Sad et al (2016) conducted a meta-analysis, which investigated the association between maths anxiety and maths achievement in Turkish students. The analysis included 11 studies, totalling 8327 students from different educational stages. The results of the analysis for all eleven studies involved showed negative and statistically significant correlations between mathematics anxiety and mathematics achievement. The combined effect size was calculated for all studies according to both fixed ($r=-.39$) and random ($r=-.44$) effect models. Moderator analysis based on school level revealed that the combined effect size for the studies conducted at both middle and high school level was significant, negative and at a moderate level. In a further study of fourth grade primary school children (Sari & Ekici, 2018), structural equation modelling revealed that maths attitude positively predicted maths achievement and negatively predicted maths anxiety. There was also a negative relationship between maths anxiety and maths achievement, although attitudes to maths was a stronger predictor. No direct relationship between motivation and maths achievement was observed.

Recber, Isiksal and Koç (2018) found only a very small difference in maths anxiety according to the gender of Turkish seventh graders. This is consistent with earlier OECD data on older students in Turkey, which demonstrated little difference between males and females. Other research in Turkey has also shown no difference in maths anxiety as a function of gender (Tasdemir, 2015; Sari & Ekici, 2018), even though girls were shown to have greater motivation (Sari & Ekici, 2018). A review of maths anxiety literature in Turkey further showed a trend towards studies typically showing no gender in maths anxiety (Alkan, 2018). Whilst gender does not appear to moderate maths affect in Turkish students, there is some evidence that maths affect does change progressively with schooling. For example, Arslan et al. (2017) observed an increase in maths anxiety as grade of study increased across middle school. Indeed, it has been argued that maths affect and attitudes only begin to be shaped upon entering formal education (Savas, Tas & Duru, 2010).

Parental maths anxiety is considered to be one of the contributing factors in the formation of maths anxiety in children (Kesici, 2018). Similarly, it is argued that positive attitudes of parents towards maths have a profound effect in developing a similar mathematical attitude in their children, which in turn supports better maths achievement (Soni & Kumari, 2017). Investigating both parent and child maths affect may provide some insight into Turkey's poor standing in maths attainment and the consistent link observed between maths attitudes, anxiety and achievement, particularly in the context of grade of study. To this end, we studied maths achievement in primary school children in Turkey, along with maths affect of child-parent dyads. Firstly, we predicted that maths affect of children and parents would predict maths achievement, with more negative affect predicting lower achievement. Secondly, we predicted that parents' maths affect would predict children's maths attitudes. Thirdly, we hypothesised maths affect would not be different between boys and girls. Next, we predicted that children's maths affect would be worse in grade four compared to grade three. Finally, it was expected that education level of parents would predict children's maths achievement.



METHODS

Design & Participants

A cross-sectional, correlational design was used. The study comprised 186 pupils (43.5% males) and their parents in grades three (50.5%, mean age = 7.8 years) and four (49.5%, mean age = 8.6 years) of a moderate socio-economic primary school in the centre of Nevşehir, Turkey. Parents included 33.3% fathers and comprised the following educational backgrounds: primary school (15.1%), middle school (15.6%), high school (25.8%), associate degree (12.4%), undergraduate degree (28.5%), master's degree (2.7%).

Materials

Math Achievement Test

The Math Achievement Test (MAT) comprises a range of numerical problem-solving questions pertaining to the math teaching programme for 1st - 4th grades in Turkey, e.g. counting numbers, number patterns, word problems, and fractions. Fidan (2013) found KR-20 coefficients of .92 for 3rd grade and .96 for 4th grade. In this study, these values were calculated as .93 for 3rd grade and .94 for 4th grade.

Primary School Math Anxiety Scale

The Primary School Math Anxiety Scale (PSMAS) includes 13 items pertaining to different aspects of maths anxiety and requires participants to respond on a Likert-type scale regarding the extent to which they experience the content of each statement. The response format has three points with labels of agree, neutral and disagree. Of the 13 items in the scale, 5 were positive and 8 were negative. The highest score on the scale was 39 and the lowest on the scale was 13. Mutlu and Soylemez (2017) reported a three-factor structure: i) *positive maths attitudes*, ii) *negative maths attitudes*, and iii) *math anxiety*. The Cronbach's alpha (α) reliability co-efficient of the overall scale was .75, with values of .73, .62 and .62 for factors one to three, respectively. The current authors agreed that the name of the scale did not fully reflect the nature of it. For instance, the scale has the same name as factor three, thus not representing "attitudes" in its labelling. Consequently, the authors relabelled the overall scale as The Child Maths Affect Scale (CMAS); this new name is referred to within the analysis and discussion of the current paper.

Math Anxiety Scale for Parents

Math Anxiety Scale for Parents includes 16 items originally purported to pertain to different aspects of maths anxiety and requires participants to respond on a Likert-type scale regarding the extent to which they experience the content of each statement. The response format has five points and ranges from "strongly disagree" to "strongly agree", with higher scores representing higher anxiety. Mutlu, Sari and Çam (2018) reported a three-factor structure: i) The emotions observed on mathematics ii) perception of failure (deficiency/inadequacy) in mathematics, and iii) The feeling of uneasiness in mathematics. The Cronbach's alpha (α) internal consistency values of the overall scale was .90, with values of .75, .85 and .88 for factors one to three, respectively. The current authors considered the labelling of the factors to be inappropriate and, in order to increase the validity of discussion and conclusions, relabelled them as follows. The first factor, the emotions observed on mathematics, was considered too vague, lacking specificity to the parents. Given the items on this factor appear to pertain to a parent's perception of their child's attitudes to maths, this was relabelled *perception of child's maths attitudes*. The second factor, perception of failure (deficiency/inadequacy) in mathematics, was considered to reflect maths self-concept or self-efficacy, whereas the items actually relate more broadly to a parent's sense of perceived difficulty in supporting their children with maths. Consequently, the second factor was relabelled *difficulty in maths support*. Finally, the third factor, the feeling of uneasiness in mathematics, was considered too vague. The items that loaded on to this factor appear to relate to the general tension and stress associated with maths learning and homework within the family environment. As such, this factor was relabelled *maths and family tension*. In addition, the authors proposed a new name for the overall scale: The Parent Maths Affect Scale



(PMAS), given that this better represents the nature of its contents. Therefore, all analyses and subsequent discussion in the current paper, whilst maintaining the proposed factor structure by Mutlu et al., make reference to these newly labelled factors and scale.

Procedure

Children in each grade completed the MAT in-class alongside the CMAS, individually and independently. A letter was sent home to parents requesting that they complete the PMAS and return it; one parent for each child completed it.

Data Analysis

Prior to data analysis, the assumption of normality was assessed. Skewness and kurtosis values were lower than the accepted threshold of 1.96 (Can, 2014) and tolerance values were sufficiently high, indicating low multicollinearity. Bivariate correlations were carried out prior to hierarchical multiple regression analyses. Between-subjects ANOVAs were used to assess group differences. Homogeneity of variance was demonstrated using Levene's test and only reported below where the assumption was not met.

RESULTS

Reliability analysis

Table 1. Internal consistency and descriptive statistics for parent and child maths affect sub-scales

	Parent maths affect scale			Child maths affect scale		Maths anxiety
	Perception of child's maths attitudes	Difficulty in maths support	Maths and family tension	Positive maths attitudes	Negative maths attitudes	
Cronbach's alpha	.778	.786	.816	.774	.477	.739
Mean total	9.30	12.96	7.51	13.47	6.55	5.45
Std.Dev.	3.33	4.62	2.96	2.13	2.11	1.99

For the parent maths affect scale, sub-scales two and three had good to very good internal consistency, whereas Cronbach's alpha for sub-scale one was very low (.478). Removal of item one increased Cronbach's alpha to .778. As such, the item was removed and a new scale total was calculated. For the child maths affect scale, sub-scales one and three had good internal consistency, whereas Cronbach's alpha for sub-scale two (*negative maths attitudes*) was very low. Removal of items did not increase internal consistency; therefore, this sub-scale was excluded from further analysis.

Table 2. Full bivariate correlations for grades three and four combined

	Perception of child's maths attitudes	Difficulty in maths support	Maths and family tension	Positive maths attitudes	Maths anxiety	Total Parent maths affect scale	Total child maths affect scale	Child maths achievement
PoCMA	1							
DiMS	.50***	1						
MaFT	.50***	.71***	1					
PMA	-.27***	-.08	-.14	1				
MA	.16*	.11	.10	-.42***	1			
Total	.77***	.90***	.86***	-.18*	.15*	1		
PMAS								
Total	-.12	.02	-.04	.59***	.49***	-.05	1	
CMAS								
CMA	-.22**	-.22**	-.26***	.08	-.37***	-.27***	-.26***	1

*p ≤ .05. **p ≤ .01. ***p ≤ .001.



Table 3. Full bivariate correlations for grade three

	Perception of child's maths attitudes	Difficulty in maths support	Maths and family tension	Positive maths attitudes	Maths anxiety	Total Parent maths affect scale	Total child maths affect scale	Child maths achievement
PoCMA	1							
DiMS	.58***	1						
MaFT	.60***	.69***	1					
PMA	-.34***	-.19	-.25*	1				
MA	.10	.13	.12	-.24*	1			
Total	.82***	.91***	.86***	-.30**	.14	1		
PMAS							1	
Total	-.22*	-.06	-.12	.67***	.56***	-.14		1
CMAS								
CMA	-.09	-.07	-.16	.035	-.50***	-.11	-.35***	1

*p ≤ .05. **p ≤ .01. ***p ≤ .001.

Table 4. Full bivariate correlations for grade four

	Perception of child's maths attitudes	Difficulty in maths support	Maths and family tension	Positive maths attitudes	Maths anxiety	Total Parent maths affect scale	Total child maths affect scale	Child maths achievement
PoCMA	1							
DiMS	.43***	1						
MaFT	.43***	.73***	1					
PMA	-.20	.02	-.02	1				
MA	-.21*	.10	.08	-.62***	1			
Total	.73***	.90***	.85***	-.07	.15	1		
PMAS							1	
Total	.01	.13	.08	.45***	.42***	.09		1
CMAS								
CMA	-.39***	-.36***	-.40***	.23*	-.29**	-.46***	-.06	1

*p ≤ .05. **p ≤ .01. ***p ≤ .001.

As shown in tables 2-4, parent maths affect was not correlated with maths affect in children. Overall, children's positive maths attitudes were negatively correlated with their self-reported maths anxiety. However, this relationship changed considerably from grade three ($r = -.24$) to grade four ($r = -.62$). Children's maths anxiety was significantly negatively correlated with their maths achievement, although the relationship was weaker in grade four ($r = -.29$) compared to grade three ($r = -.50$). Overall children's affect towards maths was correlated with their maths achievement when considering the sample as a whole. However, when considering the grades separately, results demonstrated a significant correlation for grade three ($r = -.35$) but not for grade four ($r = -.06$). Similarly, total parent maths affect scores were not correlated with children's maths achievement in grade three ($r = -.11$) but a significant negative correlation was observed in grade four ($r = -.46$); a similar pattern can be seen for all three parental sub-scales.

Sex and grade

A series of 2(child's sex) X 2(grade) between-subjects ANOVAs were carried out on total parent maths affect, total child maths affect, and children's maths achievement. Regarding total parent maths affect, there was no significant main effect of sex, $F_{(1, 182)} = 1.48, p = .23, \eta^2 = .01$, no significant main effect of grade, $F_{(1, 182)} = .00, p = .96, \eta^2 < .001$ and no significant interaction, $F_{(1, 182)} = .02, p = .89, \eta^2 < .01$. Concerning total child maths affect, there was no significant main effect of sex, $F_{(1, 181)} = 1.20, p = .23, \eta^2 = .01$, no significant main effect of grade, $F_{(1, 181)} = 1.90, p = .17, \eta^2 = .01$, and no significant interaction, $F_{(1, 181)} = 0.33, p = .57, \eta^2 < .01$. Regarding children's maths achievement, whilst there was no significant main effect of sex, $F_{(1, 182)} = 1.36, p = .25, \eta^2 < .01$, and



no significant interaction, $F_{(1, 182)} = 1.95, p = .17, \eta^2 < .01$, there was a significant main effect of grade, $F_{(1, 182)} = 27.38, p < .001, \eta^2 = .13$, whereby mean achievement in grade three was significantly higher than grade four. Means and standard deviations are displayed in Table 5.

Table 5. Means (& SDs) of parent and child maths affect and children’s maths achievement according to children’s sex and grade

Dependent variable			Grade		Total
			Third grade	Fourth grade	
Total parent maths affect	Sex	Males	28.87 (8.03)	28.76 (9.32)	28.81 (8.67)
		Females	30.36 (9.72)	30.62 (9.73)	30.49 (9.68)
	Total		29.74 (9.04)	29.77 (9.54)	29.76 (9.26)
Total child maths affect	Sex	Males	18.59 (2.24)	18.86 (1.12)	18.73 (1.75)
		Females	18.76 (2.87)	19.41 (2.11)	19.07 (2.55)
	Total		18.69 (2.62)	19.15 (1.74)	18.92 (2.23)
Child maths achievement	Sex	Males	11.36 (3.35)	9.45 (3.50)	10.37 (3.54)
		Females	11.47 (3.40)	8.18 (3.18)	9.90 (3.68)
	Total		11.43 (3.36)	8.76 (3.37)	10.11 (3.62)

Parent education status

A series of one-way between-subjects ANOVAs were conducted to assess the effect of parent education status on total parent maths affect, total child maths affect, and children’s maths achievement. There was a significant effect of parent education status on parent maths affect, $F_{(5, 180)} = 5.80, p < .001, \eta^2 = .14$. The means displayed a generally linear trend, with parent maths affect improving as education level increases. Post-hoc analysis using Tukey’s HSD demonstrated parent maths affect to be significantly worse among those with primary education compared to those with high school ($p = .05$) and University ($p < .001$) education. However, there was no significant effect of parent education status on child maths affect, $F_{(5, 180)} = 1.57, p = .17$. There was a significant effect of parent education status on children’s maths achievement, $F_{(5, 180)} = 4.27, p = .001$, with a clear linear trend towards children’s maths achievement increasing as parent education status increases. Levene’s test for homogeneity of variance indicated the variances differed significantly ($p = .009$). However, the ANOVA result remained significant after adjusting alpha to the more stringent value of .01. Follow-up analysis showed children’s maths achievement to be significantly higher for parents with an undergraduate education compared to those with a primary education ($p = .002$). Means and standard deviations are displayed in Table 6.

Table 6. Means (& SDs) of parent and child maths affect and children’s maths achievement according to parent’s education level

Parent’s education level	Measure		
	Total parent maths affect	Total child maths affect	Child’s maths achievement
Primary school	36.19 (8.76)	19.56 (1.97)	8.41 (4.46)
Middle school	30.31 (8.32)	19.38 (2.54)	9.00 (3.66)
High school	30.27 (9.14)	18.60 (1.99)	9.85 (3.82)
Associate degree	30.43 (10.22)	19.04 (2.12)	10.91 (2.79)
Undergraduate degree	25.51 (7.97)	18.47 (2.33)	11.40 (2.79)
Master’s degree	27.20 (7.33)	20.00 (2.83)	12.00 (2.45)



Regression analyses

A hierarchical multiple regression was conducted for the whole sample, with maths achievement as the outcome measure. Total parent maths affect was included in the first step and total child maths affect was included in the second step. Overall, the model was significant, $F_{(1, 182)} = 14.94$, $p < .001$, $R^2 = .14$. When included on its own in the model, parent maths affect was a significant predictor of children's maths achievement ($R^2 = .07$, $p < .001$), whereby more negative affect was associated with poorer achievement. When child maths affect was added to the model this accounted for an additional 7.2% of the variance in maths achievement, with both parent maths affect ($p < .001$) and child maths affect ($p < .001$) remaining significant predictors of maths achievement.

The same analysis was then carried out for grades three and four separately. For grade three, the overall model was significant, $F_{(1, 91)} = 8.11$, $p = .001$, $R^2 = .15$. However, whilst total child maths affect was a significant predictor of maths achievement ($p < .001$), total parent maths affect was non-significant ($p = .09$), with total child maths affect accounting for 13.8% of the total variance in maths achievement. Regarding grade four, the opposite pattern was observed. The overall model was significant, $F_{(1, 88)} = 11.25$, $p < .001$, $R^2 = .20$. When entered alone, total parent maths affect was a significant predictor of maths achievement and this remained so ($p < .001$) once total child maths affect was added to the model, whereby total child maths affect was not a significant predictor ($p = .81$). Total parent maths affect accounted for 20.3% of the variance in maths achievement.

DISCUSSION and CONCLUSIONS

In the present study, we investigated maths affect of Turkish children in grades three and four, along with maths affect in their parents and how this predicted children's maths achievement. Firstly, we predicted that maths affect of children and parents would predict maths achievement, with more negative affect predicting lower achievement. A post hoc review of the scales used indicated the measurement of more general maths affect, compared to what the original labelling of the scales indicated. Accordingly, labels of parent maths affect and child maths affect were adopted. The overall correlations were significant, supporting the hypothesis. There was a small-to-medium negative correlation for both parental and child maths affect when data were collapsed across both grades. However, on closer inspection, a different pattern of results emerged as a function of grade. In grade three, there was no relationship between parent maths affect and children's maths achievement, but child maths affect significantly, moderately correlated with their maths achievement. Conversely, in grade four, there was no significant correlation between child maths affect and maths achievement, but there was a strong significant correlation between parent maths affect and children's maths achievement. Multiple regression analyses revealed child maths affect accounted for 13.8% unique variance in maths achievement in grade three, whereas parent maths affect accounted for 20.3% unique variance in maths achievement in grade four.

In contrast to what was hypothesised, there was no overall relationship between children's and parents' maths affect. However, it is important to note the factors that constitute the parent maths affect scale. Perception of child's maths attitudes may say more about the child's attitudes and behaviours displayed outside of the classroom. This could explain heightened frustration, for example, as learning becomes more assessment focused when children progress from grade three to grade four. Indeed, according to Sari et.al (2015), the competitive examination system in Turkey contributes to students' negative attitudes to maths. Difficulty in maths support to some extent may reflect parents' maths self-efficacy. Items on this sub-scale pertain to a parent's perceived difficulty in supporting their child with maths work. As children progress to grade four the work becomes more challenging and the importance of success becomes increasingly heightened. Post hoc analysis revealed parent education level to be a significant predictor of difficulty in maths support. Therefore, we tentatively suggest that the consequences of parents' difficulties in supporting children in their maths learning become enhanced during grade four. This proposition is further supported by the finding that children's maths achievement was directly related to educational level of the parent.



Further work is needed to investigate specific home numeracy practices, particularly how these may relate to maths attitudes of children and parents. Indeed, Del Rio et al (2017) provided some evidence that parental maths anxiety influences formal home numeracy practices, whereby those with lower maths anxiety were more likely to engage in advanced numeracy practice with their children. Finally, maths and family tension, may reflect the general levels of stress experienced in the home when it comes to parents supporting their child's maths learning. Consistent with the idea that children face more pressure as they move to a more assessment focused grade four, it is clear to see how this is then related to children's maths achievement in grade four. It is also consistent with the observed relationship between difficulty in maths support and children's maths achievement in grade four, but not grade three. Difficulty in maths support was strongly correlated with maths and family tension in grades three and four, suggesting a consistent relationship exists. It is possible that parents' perceived difficulty in supporting children's maths learning may be a causative factor of perceived family tension around maths. Such a proposition is substantiated by the findings that parent's education level is associated with difficulty in maths support and children's maths achievement, although further work is required to support this. It is also feasible that children's positive attitudes to maths mitigates some of the pressures experienced as children progress through the grades. The relationship between children's positive attitudes to maths and maths anxiety changed from -0.24 in grade three to -0.62 in grade four, highlighting the importance of positive attitudes through the transition to grade four.

The prediction that there would not be a sex difference in maths attitudes/affect was supported. Despite many findings regarding a female bias towards higher maths anxiety (Hembree, 1990; Devine et al., 2012), 2013 OECD data failed to show a difference between boys and girls in Turkey. There is also evidence to suggest a general trend in sex differences in maths anxiety might not appear until adolescence, with some studies findings no difference between boys and girls in primary school (Harari et al., 2013) and others finding mixed results (Ho et al., 2000). Whilst we predicted child maths affect to increase with grade of study, we found no significant main effect of grade. This is in contrast with other findings (e.g. Arslan et al., 2017), but it may also be the case that a wider range of grades needs to be included for differences to emerge.

Our final hypothesis was supported, whereby children's maths achievement significantly varied as a function of parents' education level. Indeed, there was a clear, linear pattern in which children's maths achievement became poorer as parents' education level decreased; on average, maths achievement in children whose parents had an undergraduate degree achieved grades 35.55% higher than children whose parents were educated to primary level. There is empirical evidence to suggest that students with parents who provide more support display higher maths achievement and a more positive attitude towards maths than students with parents who provide less support (Cai, Moyer, & Wang, 1999). Also, Silinskas and Kikas (2017) assessed perceived parental involvement in maths homework and maths performance in sixth graders. They found maths performance to be lower in children who perceived their parents to be controlling in homework situations. Conversely, those who perceived their parents as being supportive performed better. Similarly, Levpuscek and Zupancic (2009) found parental pressure negatively correlated with maths achievement in eighth graders. A similar pattern has been observed in undergraduates. Macmull and Ashkenazi (2019) asked students to report on their maths self-efficacy, maths anxiety and the parenting style of their mother. They found that an authoritarian parenting style predicted higher maths anxiety. This parenting style is characterised by a restrictive and controlling environment, typically involving more punishments than rewards (Baumrind, 1968). Such parents may also lack affection and warmth (Furnham & Cheng, 2000). Research has also shown that parents' attitudes about education are conveyed to their children out of school and these attitudes are reflected in the child's classroom behaviour and in teachers' relationships with parents and children (Kellaghan et al., 1993). Parenting practices, including pressure to maintain high achievements (Daches Cohen and Rubinsten, 2017), and parental involvement in maths learning processes (Vokovic et al., 2013), appear to be associated with children's maths anxiety. In particular, maths homework may be a source of stress for some families,



with evidence to suggest that parental maths anxiety may in some way transfer to children through homework support (Maloney et al, 2015). Thus, it may be important to consider what is meant by parental support and how such support interacts with individual differences in parents, such as maths attitudes, maths self-efficacy, and level of maths education. Whilst it seems that parenting style is an important factor to consider when it comes to the home numeracy environment, this is something that should be explored in the context of emotion and maths learning.

We should highlight that, whilst the sex of the children was taken into account in the current study, there was insufficient data to assess the impact of parental sex. Previous work has demonstrated the importance of considering interactions between children and parents of the same or different sex (Casad, Hale, & Wachs, 2015). For example, Daches Cohen and Rubinsten (2017) found the most significant parental maths anxiety effect in mother-daughter dyads. Furthermore, recent work (Szczygieł, 2020) demonstrated a complex pattern of relationships concerning the relationship between children's and parents' gender, maths anxiety, grade of study, and children's maths achievement. Future work would therefore benefit from recording details of which parent is most involved in supporting their child's maths learning and to record maths anxiety and attitudes of both parents where possible. It is also important to note that parent maths affect, as studied in the current study, does not enable inferences to be made concerning cause and effect; it is unknown whether parent maths affect directly impacts a child's maths achievement. For instance, it is possible that the relationship between family tension and maths achievement is bidirectional.

In sum, our findings point towards a step change from grade three to grade four in maths achievement and its predictors. Whilst child maths affect was a predictor of maths achievement in grade three, with no influence of parent maths affect, this pattern reversed in grade four. All three sub-scales of the parent maths affect scale predicted children's maths achievement in grade four: perceived child's maths attitudes, difficulty in maths support, and maths and family tension. In combination with the observed negative relationship between parent education level and children's maths achievement, this study highlights the relevance of considering the affective domain within home numeracy as maths becomes more challenging and assessment focused. The findings emphasise the need to support parents who have limited maths education and may struggle to support their children with their maths learning.

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