Early Child Development and Care

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/gecd20

Understanding the role of parental self-efficacy for supporting children's early learning in the home mathematics environment

Laura A. Outhwaite, Natalie Marie Fischer, Anna S. Jusek & Jo Van Herwegen

To cite this article: Laura A. Outhwaite, Natalie Marie Fischer, Anna S. Jusek & Jo Van Herwegen (05 Mar 2025): Understanding the role of parental self-efficacy for supporting children's early learning in the home mathematics environment, Early Child Development and Care, DOI: 10.1080/03004430.2025.2474668

To link to this article: https://doi.org/10.1080/03004430.2025.2474668

Published online: 05 Mar 2025.

EARLY CHILD DEVELOPMENT AND CARE
https://doi.org/10.1080/03004430.2025.2474668

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Understanding the role of parental self-efficacy for supporting children's early learning in the home mathematics environment

Laura A. Outhwaite [a,b], Natalie Marie Fischer[c], Anna S. Jusek[a] and Jo Van Herwegen [a,b,c]

[a]Centre for Education Policy and Equalising Opportunities, IOE, UCL's Faculty of Education and Society, London, UK; [b]Centre for Educational Neuroscience, Department of Psychological Sciences, Birkbeck University of London, London, UK; [c]Psychology and Human Development Department, IOE, UCL's Faculty of Education and Society, London, UK

ABSTRACT

Alongside formal education, the home mathematics environment is important for children's early maths development. This study reports a new domain-specific measure of parental self-efficacy for maths (and reading skills) with 3–4-year-olds. 65 families in the UK were surveyed, and a sub-sample of 40 families also completed a remote child assessment session. Results showed that the new parental self-efficacy measure had acceptable internal consistency and that parents had higher self-efficacy for supporting their child's reading, compared to their maths skills. The new measure of parental self-efficacy for maths was also found to predict the frequency of maths-related home activities. Parental self-efficacy for maths was not significantly associated with parental maths anxiety. This evidence highlights the role of parental self-efficacy for maths as an affective factor within the home mathematics environment and suggests it is an important near-transfer target for parent-focused maths interventions, which seek to improve children's maths outcomes.

ARTICLE HISTORY
Received 29 April 2024
Accepted 25 February 2025

KEYWORDS
Mathematical development; home mathematics environment; parental self-efficacy; early years; informal maths activities

Introduction

Strong foundations in early mathematical skills are vital for later mathematical learning and development (Bailey et al., 2020; Ten Braak et al., 2022). However, significant attainment gaps in mathematical skills emerge before children start school (James-Brabham et al., 2023) and persist over time (Aubrey et al., 2006). This has long-term implications for children's education, employment, and health outcomes (Butterworth et al., 2011; Crawford & Cribb, 2013; Davis-Kean et al., 2021; Watts et al., 2017). These attainment gaps may arise, in part, due to individual differences in the home mathematics environment, which plays an essential role in children's maths development, alongside formal education (Daucourt et al., 2021; Eason et al., 2022; Hornburg et al., 2021).

Home mathematics environment

Grounded in sociocultural learning theory (Vygotsky, 1978; Rogoff, 2003), the home mathematics environment is defined as all social interactions between caregivers and children in (and around)

CONTACT Laura A. Outhwaite l.outhwaite@ucl.ac.uk Centre for Education Policy and Equalising Opportunities, IOE, UCL's Faculty of Education and Society, 20 Bedford Way, London, WC1H 0AL, UK

the home that is related to mathematics (Eason et al., 2022; Hornburg et al., 2021). This includes caregivers' expressions of their maths-related attitudes, beliefs, and expectations, as well as maths-related conversations and activities that caregivers and children might take part in (Berkowitz et al., 2021; Mutaf-Yıldız et al., 2020; Silver & Libertus, 2022). Skwarchuk et al. (2014) differentiate between formal and informal maths activities. Formal maths activities involve structured, intentional interactions where caregivers actively teach early maths concepts to enhance their children's skills (e.g. practising counting skills and simple mathematical operations). In contrast, informal maths activities arise incidentally during shared experiences where the primary focus is not on teaching maths, but mathematical learning may still occur (e.g. playing a game with numbers). A recent meta-analysis of 64 studies showed the quality of children's home mathematics environments was positively associated with maths attainment outcomes, particularly in the early years (Daucourt et al., 2021). For example, longitudinal research shows the frequency of formal and informal maths activities in the home, as well as the application of maths concepts into everyday situations, such as shopping and cooking, are significantly associated with children's early maths skills and language use (Napoli & Purpura, 2018; Susperreguy et al., 2020; Zhang et al., 2020). Intervention studies also demonstrate emerging evidence that providing caregivers with guidance on how to implement maths activities with their children can improve the frequency of learning opportunities in the home mathematics environment and support children's maths outcomes (Leyva et al., 2023; Libertus, 2024; Vandermaas-Peeler et al., 2012).

However, despite this evidence demonstrating the importance of the home mathematics environment, other research shows families' maths engagements are less frequent compared to reading (OECD, 2020). This 'maths-practice gap', relative to reading (Stacy et al., 2017) may arise due to affective factors, such as low parental self-efficacy for supporting children's maths skills and/or high parental maths anxiety (Dowker, 2021; Keating et al., 2022).

Parental self-Efficacy

Self-efficacy and social cognitive theories emphasise the role of beliefs in one's ability to organise and execute actions to succeed in specific situations, which underpins motivation and behaviour (Bandura, 1977). For example, parental self-efficacy can be defined as caregivers' beliefs about their ability to support their children's educational outcomes through their involvement in the learning process (Hoover-Dempsey & Sandler, 2005). The Revised Parental Involvement Process (R-PIP) model proposes that parental self-efficacy is a key component of parents' motivational beliefs, which underpin parental involvement behaviours (Hoover-Dempsey & Sandler, 1995, 1997, p. 2005). In support of this R-PIP model, research shows significant associations between parental self-efficacy and parental involvement in learning activities, as well as children's learning outcomes (Albanese et al., 2019; Bojczyk et al., 2018). Often these studies used a global measure of parental self-efficacy. For example, Bojczyk et al. (2018) used the Parent Self-Efficacy scale, which focuses on love, control, communication, education, and general efficacy (Duke et al., 1996). Bojczyk et al. (2018) also emphasised the need for domain-specific measures of parental self-efficacy for understanding associations with specific child learning outcomes, such as maths and reading.

Wu et al. (2022) measured parental self-efficacy for maths with six items adapted from Hoover-Dempsey and Sandler's (1997) global parental self-efficacy items on a 10-point Likert scale (e.g. 'I know how to help my child do well in math'). Results showed higher parental self-efficacy for maths was associated with increased engagement with children's maths homework and informal learning activities (e.g. measuring while cooking) in the first and second year of primary (i.e. elementary) school. However, given the age of the sample (6-8 years), the items did not fully capture parental self-efficacy for play-based approaches to mathematical learning, which may be more appropriate for younger children, before they start school (Skene et al., 2022).

For example, the play sub-scale from the Short Form of the Self-efficacy for Parenting Tasks Index-Toddler Scale (SEPTI – TS; Van Rijen et al., 2014), includes items such as 'I can always think of

something to play with my child'. While this measure has been used to examine associations between parental self-efficacy, parental physical health, and fathers' involvement in early child development (Garcia et al., 2022; Cordts et al., 2020), there are very few studies examining how parental self-efficacy for supporting children's early maths and early literacy skills are related to the frequency of home learning activities and children's outcomes. Keating et al. (2022) surveyed families of children aged 4–5 years and found higher parental self-efficacy for maths and literacy was significantly associated with more frequent home learning activities. However, while parents reported more time spent on literacy compared to maths activities, no significant difference was observed between parental self-efficacy for literacy compared to maths. This may, in part, be due to the measure of parental self-efficacy, which consisted of one item for maths and literacy each, on a three-point Likert scale, and the observed ceiling effects. Collectively, this evidence suggests domain-specific measures of parental self-efficacy for supporting children's maths and reading skills are needed, which are suitable for use in the early years, before children start school.

Parental maths anxiety

Alongside parental self-efficacy, parental maths anxiety may also be an affective factor within the home mathematics environment (Dowker, 2021). Maths anxiety is defined as 'feelings of tension, apprehension, or fear that interferes with maths performance' (Ashcraft, 2022, p. 181), and is distinct from general anxiety (Malanchini et al., 2020). Longitudinal research shows that higher parental maths anxiety significantly predicts lower maths outcomes for children in the first year of school, independent of parents' own maths abilities (Simmons et al., 2024). The Parent and Child Math Anxiety Network model proposes that parents' experiences of maths anxiety may, in part, be related to children's maths outcomes via the quantity and quality of parent–child maths interactions (Carkoglu et al., 2023). For example, some studies show a significant negative association between parental maths anxiety and the frequency of maths-related learning activities and conversations in the home with preschool aged children (Berkowitz et al., 2021; Elliott et al., 2020). Longitudinal evidence also suggests at the start of school, children of maths-anxious parents learnt significantly less maths and reported their own higher maths anxiety over the school year, but only when their maths-anxious parent provided frequent and well-meaning help with homework (Maloney et al., 2015).

Collectively, this evidence suggests parental self-efficacy for supporting children's maths skills and parental maths anxiety are distinct affective factors within the home mathematics environment, which may affect children's maths outcomes. However, research to date has largely considered these affective factors independent of each other (e.g. Berkowitz et al., 2021; Keating et al., 2022; Simmons et al., 2024). Other studies with older children (10-15 years) suggest there are relationships between children's (not parental) self-efficacy, maths anxiety, and attainment outcomes (Kalaycıoğlua, 2015; Živković et al., 2023). Research with teachers also shows a significant negative association between maths anxiety and self-efficacy for teaching maths (Swars et al., 2006), and these affective factors are associated with the frequency of maths activities in the classroom environment (Costa et al., 2023). To our knowledge, these relationships have not been examined with parents. As such, further research is needed to consider how these affective factors are related to each other within the context of the parent–child dynamic in the home mathematics environment.

Current study

The current study had two aims. First, to develop new domain-specific measures of parental self-efficacy for supporting children's maths and reading skills, which are suitable for use in the early years, before children start school. Second, to examine how the new measure of parental self-efficacy for maths was associated with frequency of maths-related home activities, children's maths outcomes in the early years before the start of school, and parental maths anxiety. To address these aims, this study asked three research questions (RQ) with the following hypotheses:

RQ1: Do parents have higher self-efficacy for supporting their child's reading skills, compared to their maths skills? Although previous studies did not find a significant difference (Keating et al., 2022), it was predicted that parents would report higher self-efficacy for reading than maths on the new measure of domain-specific parental self-efficacy designed in this study.

RQ2: What is the relationship between parental self-efficacy for maths and the frequency of maths related activities in the home and children's maths outcomes? Based on the R-PIP model (Hoover-Dempsey & Sandler, 1995, 1997, p. 2005) and previous studies (Keating et al., 2022; Wu et al., 2022), positive associations between these variables were predicted.

RQ3: What is the relationship between parental self-efficacy for maths and parental maths anxiety? Although there is little existing evidence (Swars et al., 2006), it was predicated that lower self-efficacy for maths would be associated with higher levels of parental maths anxiety.

Materials and methods

Participants

Sixty-five families with children aged 3–4 years from across the United Kingdom (UK) were recruited through opportunity sampling via social media, including Instagram, Facebook, X (formerly known as Twitter), and via professional networks of the research team. Table 1 summarises the demographic

Table 1. Descriptive characteristics of the families in the whole sample (n = 65) and sub-sample (n = 40).

Descriptive Data	Whole Sample (n = 65)	Sub-Sample (n = 40)
Parents		
Age (years) Mean (SD), Min-Max	37.20 (3.86), 30.00-45.00	37.43 (3.85), 30.00-45.00
Gender		
Female	60 (92.3%)	38 (95.0%)
Male, or Prefer not to say	5 (7.7%)	2 (5.0%)
Ethnicity		
White British	39 (60%)	21 (52.5%)
Indian	9 (13.8%)	8 (20.0%)
Black or Black British, Pakistani & Bangladeshi, or Mixed	8 (12.3%)	8 (20.0%)
Other, or Prefer not to say	9 (13.8%)	3 (7.5%)
Highest Level of Education (General)		
Postgraduate (e.g. MSc, PGCE, PhD)	40 (61.5%)	24 (60.0%)
Undergraduate (e.g. BSc, BA)	19 (29.2%)	13 (32.5%)
Further vocational training (e.g. NVQ), School leaving qualifications, or Other	6 (9.2%)	3 (7.5%)
Highest Level of Mathematics Qualification		
Postgraduate (e.g. MSc, PGCE, PhD)	5 (7.7%)	5 (12.5%)
Undergraduate (e.g. BSc, BA)	5 (7.7%)	4 (10.0%)
School leaving qualifications or Other	55 (87.7%)	31 (77.5%)
Children		
Child age (months) Mean (SD), Min-Max	45.57 (5.87), 34.00-59.00	45.75 (6.54), 34.00-59.00
Gender of child		
Female	33 (50.8%)	21 (52.5%)
Male, or Prefer not to say	32 (49.2%)	19 (47.5%)
Ethnicity		
White British	38 (58.4%)	21 (52.5%)
Mixed	10 (15.4%)	8 (20.0%)
Indian	6 (9.2%)	5 (12.5%)
Black or Black British, Pakistani & Bangladeshi, or Other	11 (16.9%)	6 (15.0%)
English as an Additional Language		
Yes, or Prefer not to say	8 (12.3%)	4 (10.0%)
No	57 (87.7%)	36 (90.0%)
Identified Special Educational Needs		
Yes, or Prefer not to say	9 (13.9%)	3 (7.5%)
No	56 (86.2%)	37 (92.5%)

characteristics of the whole sample (n = 65) and the sub-sample of families who also completed the remote child assessment session (n = 40).

Materials

Data for the current study came from the pre-test online survey and remote child assessments of a larger, ongoing study evaluating the impact of a new digital application (app) for parents, which is designed to encourage families' maths-related home activities and support children's maths development . The online survey included measures of parental self-efficacy for maths and reading, frequency of maths-related home activities, parental maths anxiety, and parental education and other demographic information.

Parental self-efficacy for maths and reading. Parental self-efficacy for supporting children's maths skills was measured on a 14-item questionnaire designed specifically for this study. For example, 'I know how to help my child do well in maths'. These 14 items were then adjusted to reflect parental self-efficacy for reading. For example, 'I know how to help my child do well in reading' (see Appendix for all items). The 14 items were adapted from existing questionnaires, including the play sub-scale from the Short Form for the Self-Efficacy for Parenting Tasks Index – Toddler Scale (SEPTI-TS; Van Rijen et al., 2014) and the Parental Self-Efficacy for Helping the Child to Succeed in School sub-scale (Walker et al., 2005) developed from Hoover-Dempsey and Sander's (1995, 1997) theoretical model of parental involvement processes. The 14 items were measured on a 6-point Likert scale (strongly disagree scored 1 to strongly agree scored 6) with a maximum total score of 84. Higher scores indicated higher parental self-efficacy for supporting maths (and reading) at home. These new measures of parental self-efficacy for maths and reading had acceptable levels of internal consistency (see Table 2).

Frequency of maths-related home activities. The frequency of maths-related home activities was measured using the Frequency of Household Activities subscale from Pre-school Home Mathematics Questionnaire (Cahoon et al., 2021). This measure included 22 items across four factors, including counting (5 items), parent–child interaction (8 items), TV programmes (3 items), and shape (6 items). The 22 items were measured on a 4-point Likert scale (Few times a month scored 1 to Almost daily scored 4, with Activity did not occur scored 0) with a maximum total score of 88. Higher scores indicated greater frequency of maths-related home activities. This measure has established psychometric properties with caregivers of 3-5-year-olds (Cahoon et al., 2021) and had acceptable levels of internal consistency in the current study (see Table 2).

Parental maths anxiety. Parental maths anxiety was measured using the Abbreviated Maths Anxiety Scale (Hunt et al., 2011). Parents were asked to rate how anxious they would feel in nine different mathematics-related scenarios, such as 'taking a maths test'. Parents respond on a 5-point Likert scale (Low anxiety scored 1 to High anxiety scored 5) with a maximum total score of 45. Higher scores indicated higher maths anxiety. This measure has established psychometric

Table 2. Descriptive data for study variables, including affective factors, frequency of maths-related home activities, and TEMA-3 scores (Total raw scores).

Measures	*n*	Cronbach alpha	Mean (SD)	Min – Max
Affective Factors				
Parental Self-Efficacy Maths	65	.86	55.11 (9.59)	36.00–76.00
Parental Self-Efficacy Reading	65	.85	62.78 (8.78)	39.00–79.00
Parental Maths Anxiety	65	.94	21.77 (9.11)	9.00–42.00
Frequency of Maths-Related Home Activities				
Overall Frequency of Household Activities	65	.90	42.89 (15.51)	3.00–74.00
Counting Factor	65	.76	13.60 (4.93)	1.00–20.00
Parent-Child Interactions Factor	65	.81	12.74 (6.80)	0.00–29.00
TV Programmes Factor	65	.87	5.15 (3.45)	0.00–12.00
Shape Factor	65	.73	11.40 (4.54)	0.00–22.00
Children's Maths Skills				
TEMA-3	40	–	13.18 (8.03)	1.00–32.00

properties with adults in the UK (Hunt et al., 2011) and had acceptable levels of internal consistency in the current study (see Table 2).

Parental education and other demographic information. Parental education, including the level of attainment by the parent specific to mathematics was measured via self-reported responses to the following questions, respectively: What is your highest level of education? What is your highest level of mathematical achievement (including any statistical training)? The following responses categories were available for both questions: No formal qualification, School leaving certificate (e.g. GCSE or A Levels), Further vocational training (for specific industry), University degree or equivalent (e.g. BA or BSc), Postgraduate degree or equivalent (e.g. MA, MSc, or PhD), or Other. Other demographic information, including parent age, gender, and ethnicity, as well as child age, gender, ethnicity, English as an Additional Language status, and identified special educational needs, were also collected via the self-report survey.

Children's maths skills. For a sub-sample of families (n = 40), children's maths skills were also measured using the Test of Early Mathematical Abilities – Third Edition (TEMA-3; Form A; Ginsburg & Baroody, 2003) in a remote child assessment session. TEMA-3 is a standardised mathematical assessment tool, which measures formal and informal early maths skills, including magnitude comparison, counting, calculation and number facts, with children aged 3–8 years. Total raw scores are reported in the current study.

Procedure

Parents completed the questionnaires on self-efficacy, maths anxiety, their level of education and activities at the home online via Qualtrics. The entire online survey took between 20–30 min to complete. Opt-in informed consent was obtained from all parents at the start of the survey. After parents completed the online survey, their child was invited to participate in a remote child assessment session. Sessions were conducted on a one-to-one basis by a member of the research team via Microsoft Teams. Remote child assessments took approximately 1 h to complete. Opt-in informed consent was obtained again from all parents, as well as child assent at the start of the video call. Research shows these remote data collection procedures are as reliable and valid as face-to-face data collection (Ashworth et al., 2021). The study received ethical approval from the IOE ethics committee (REC1778). All results are reported at a two-tailed level of probability.

Results

Descriptive data for study variables are reported in Table 2 with a Pearson's correlation matrix between relevant variables summarized in Table 3. No significant outliers were observed. The *p*-values reported in Table 3 include Bonferroni corrections.

Parental self-efficacy for maths and reading (RQ1)

A paired samples t-test showed that parents reported, on average, significantly higher self-efficacy for supporting their child's reading skills, compared to their child's maths skills, $t(64) =$

Table 3. Pearson's correlation matrix between parental self-efficacy for maths, parent maths anxiety, frequency of maths-related home activities, and children's TEMA-3 scores.

	Correlations (*r*)		
Measures	2	3	4
1. Parental Self-Efficacy Maths	−.22	.62**	.33[a]
2. Parental Maths Anxiety	-	−.16	−.04
3. Total Frequency of Maths-Related Activities	-	-	.28
4. Children's TEMA-3 maths scores	-	-	-

** $p < .001$ [a]$p = .041$, Bonferroni corrected *p*-value = .013

7.15, $p < .001$. This was characterised by a large effect size of .83 (Cohen's *d*; 95% confidence interval .33- 1.34).

Frequency of maths-related home activities (RQ2)

A shown in Table 3, a significant positive relationship was observed between parental self-efficacy for maths, and the overall frequency of maths related activities in the home. This relationship was consistent across the four different household activity factors; counting, $r = .54$, $p < .001$, parent–child interactions, $r = .57$, $p < .001$, TV programmes, $r = .41$, $p < .001$, and shape, $r = .42$, $p < .001$. A linear regression model showed that parental self-efficacy for maths remained a significant predictor of overall frequency of maths activities in the home when other factors were accounted for, including parent's highest level of education, highest level of mathematics qualification, their maths anxiety score, and other demographic factors (i.e. ethnicity) (see Table 4).

Children's maths outcomes (RQ2)

A positive correlation was found between parental self-efficacy for maths, and children's TEMA-3 scores (see Table 3). However, this relationship did not remain significant when Bonferroni corrected *p*-values were used ($\alpha = .05/4 = .013$). A small positive correlation was also found between the overall frequency of maths related activities in the home and children's TEMA-3 scores, but this relationship did not reach statistical significance (see Table 3). However, when examining the relationships between the four household activity factors and children's TEMA-3 scores, a significant positive correlation was found for the parent–child interactions factor, $r = .45$, $p = .003$. The remaining three factors were not significant; counting, $r = .23$, $p = .148$, TV programmes, $r = .12$, $p = .462$, shape, $r = -.04$, $p = .789$. As shown in Table 4, a linear regression model showed that children's TEMA-3 scores were only predicted by frequency of parent–child interactions. The other predictors were not significant.

Maths anxiety (RQ3)

A Pearson's correlation showed a weak negative correlation between parental self-efficacy for maths and parental maths anxiety. However, in this sample, this relationship did not reach statistical significance (see Table 3).

Table 4. Linear regression models to explain variance in frequency of maths-related home activities and children's TEMA-3 scores.

	Model		Significance	Change		Unstandardized Coefficients	Standardized Coefficients	Significance
Predictor variables	R	R^2	*F* (df), *p*	DR^2	Sig. DF	B, Std. Error	Beta	*t*, *p*
Frequency of Maths-Related Home Activities								
Parental Self-Efficacy Maths	.66	.439	**8.44 (5), *< .001***	.439	<.001	1.13, .189	**.67**	**5.96, <.001**
Parental Highest Maths Qualification						−.33, 1.93	−.02	−.17, .867
Parental Highest Level of Education						1.94, 2.70	.08	.72, .476
Parental Maths Anxiety						−.03, .18	−.02	−.17, .869
Parent Ethnicity						1.77, 1.01	.21	1.76, .085
Children's TEMA-3 scores								
Parent-Child Interactions	.55	.298	**2.89 (5), *.028***	.298	.028	.660, .262	**.59**	**2.52, .017**
Parental Self-Efficacy Maths						.139, .160	.17	.867, .392
Counting						−.187, .418	−.11	−.447, .658
TV Programmes						−.197, .385	−.09	−.511, .613
Shape						−.472, .299	−.27	−1.58, .124

Discussion

This study reports on a new domain-specific measure of parental self-efficacy for maths and reading skills with children aged 3–4 years, before the start of formal school. Using this new measure, this study also examined how parental self-efficacy for maths is situated within the home mathematics environment through its associations with the frequency of maths-related home activities, and children's maths outcomes. The current findings are of particular significance to developing strong theoretical models of the home mathematics environment. The findings also demonstrate the importance of parental self-efficacy for maths as a near-transfer target for parent-focused interventions in the early years.

Parental self-Efficacy for maths and Reading

As predicted, results showed that parents reported, on average, higher levels of self-efficacy for supporting their child's reading skills at home, compared to their child's maths skills. In answering this research question, the current study addresses the limitations of previous research, which measured domain-specific parental self-efficacy for supporting children's maths and literacy with one item in each skill domain (Keating et al., 2022). Furthermore, the new parental self-efficacy items for maths and reading developed in the current study also address the need for domain-specific measures of parental self-efficacy targeting early maths and reading skills (Bojczyk et al., 2018). Specifically, the current findings demonstrated that the new parental self-efficacy maths and reading items had acceptable internal consistency and are thus suitable for use in future studies in this area.

Frequency of maths-related home activities

The parental self-efficacy for maths items were also significantly associated with the frequency of maths-related home activities, including when controlling for parent's highest level of education, highest maths qualifications, maths anxiety and other demographic factors (i.e. ethnicity). Consistent with the R-PIP model (Hoover-Dempsey & Sandler, 1995, 1997, p. 2005) and other previous studies (Keating et al., 2022; Wu et al., 2022), this evidence emphasises the importance of parental self-efficacy for maths for creating positive home mathematics environments for young children.

Children's maths outcomes

Furthermore, in line with the R-PIP model (Hoover-Dempsey & Sandler, 1995, 1997, p. 2005) a small, positive correlation between parental self-efficacy and children's maths outcomes was observed. However, contrary to predictions this relationship did not reach statistical significance when Bonferroni corrected *p*-values were used. A small, positive correlation between overall frequency of maths-related home activities and children's maths outcomes was also observed. Although, this relationship did not reach statistical significance, the size of the correlation was in line with other similar studies in the field (Daucourt et al., 2021).

The lack of statistical significance for these findings relating to children's maths outcomes may be, in part, due to the smaller sub-sample size (n = 40), relative to the whole sample in the current study (n = 65). As such, these analyses may be underpowered. Additionally, for the frequency of maths-related home activities findings, it may also reflect some of the challenges associated with accurately capturing this information. Specifically, self-reported, retrospective accounts from parents, such as those used in this study, may not fully capture children's experiences in the home mathematics environment (Hornburg et al., 2021; Missall et al., 2017). Nevertheless, when considering the four different factors within the frequency of maths-related home activities measure, the parent–child interaction factor was significantly correlated with children's maths outcomes and remained a

significant predictor when controlling for parental self-efficacy for maths and the remaining three frequency factors (Counting, TV programmes, and Shape).

Collectively, this evidence highlights the value of parental self-efficacy as a target for intervention (Albanese et al., 2019). Specifically, the current evidence suggests that parental self-efficacy for maths should be considered an essential near-transfer outcome measure in the evaluation of any parent-focused interventions, which aim to improve the quantity and quality of maths-related home activities, and as a result, also improve children's maths outcomes.

Parental maths anxiety

Contrary to predictions, results showed that although a negative correlation between parental self-efficacy and maths anxiety was observed, it was not statistically significant in the current sample. Parental maths anxiety also did not significantly correlate with the frequency of maths-related activities and child's maths outcomes, which is inconsistent with evidence from the Parent and Child Math Anxiety Network model (Carkoglu et al., 2023). These findings may also be explained by the relatively small sample size in the current study and should thus be interpreted with caution. However, these results could suggest that parental self-efficacy is a more important affective factor to consider (and target through intervention) within the home mathematics environment, relative to parental maths anxiety. Further research is needed to explore this hypothesis.

Limitations and future directions

The current study aimed to develop new domain-specific measures of parental self-efficacy for supporting children's maths and reading skills. Although the items demonstrated strong internal consistency, as well as significant predictive validity with the frequency of maths-related home activities and children's maths outcomes, the psychometric evaluation of these new measures should be further established. For example, test-retest reliability, structural validity, and criterion validity with gold-standard parental self-efficacy measures should also be evaluated, including in line with common acceptability thresholds (Outhwaite et al., 2024).

Furthermore, although the current study focused on two important affective factors; parental self-efficacy and parental maths anxiety, other studies also highlight the importance of parent's expectations and value of maths (Kiss & Vukovic, 2020; Mues et al., 2022; Silver et al., 2021). The sample within the current study also primarily consisted of mothers (92%). Future research should further examine parents' maths-related attitudes, beliefs, and expectations across genders to build a holistic understanding of parental processes in the home mathematics environment.

Future research would also benefit from larger sample sizes than the current study. This would be particularly beneficial for further examining potential racial/ethnic differences in parental self-efficacy in the home mathematics environment. For example, although no ethnicity differences were observed in the current study, previous longitudinal cohort studies in the USA have shown that Asian and White children have significantly higher maths scores when they start school, compared to their Black and Latino peers. These differences were shown to be associated with the frequency of maths home engagements (Sonnenschein & Sun, 2017).

Conclusion

Building on existing theoretical frameworks for parental involvement process (Hoover-Dempsey & Sandler, 1995, 1997, p. 2005), the current study provides a new measure of parental self-efficacy for maths (and reading) with families of 3-4-year-olds before the start of formal school. Overall, this study highlights the importance of parental self-efficacy for maths for understanding affective factors in the home mathematics environment. It also emphasises the value of parental self-efficacy for maths as a near-transfer target for parent-focused interventions, which seek to

enhance the quantity and quality of maths-related home activities, and thus improve children's early maths outcomes.

Acknowledgements

We would like to thank all the families who completed the online survey and remote child assessment session. We would also like to thank Dr Hayley Frances-Hunt Spurin, Aria Ansara, and Jaimie Ka Ya Leung for their assistance with data collection.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Laura A. Outhwaite http://orcid.org/0000-0002-4454-7775
Jo Van Herwegen http://orcid.org/0000-0001-5316-1818

References

Albanese, A. M., Russo, G. R., & Geller, P. A. (2019). The role of parental self-efficacy in parent and child well-being: A systematic review of associated outcomes. *Child: Care, Health and Development*, *45*(3), 333–363. https://doi.org/10.1111/cch.12661

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science*, *11*(5), 181–185. https://doi.org/10.1111/1467-8721.00196

Ashworth, M., Palikara, O., Burchell, E., Purser, H., Nikolla, D., & Van Herwegen, J. (2021). Online and face-to-face performance on two cognitive tasks in children with Williams syndrome. *Frontiers in Psychology*, *11*, 594465. https://doi.org/10.3389/fpsyg.2020.594465

Aubrey, C., Godfrey, R., & Dahl, S. (2006). Early mathematics development and later achievement: Further evidence. *Mathematics Education Research Journal*, *18*(1), 27–46. https://doi.org/10.1007/BF03217428

Bailey, D. H., Oh, Y., Farkas, G., Morgan, P., & Hillemeier, M. (2020). Reciprocal effects of Reading and mathematics? Beyond the cross-lagged panel model. *Developmental Psychology*, *56*(5), 912. https://doi.org/10.1037/dev0000902

Bandura, A. (1977). Self-Efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Berkowitz, T., Gibson, D. J., & Levine, S. C. (2021). Parent math anxiety predicts early number talk. *Journal of Cognition and Development*, *22*(4), 523–536. https://doi.org/10.1080/15248372.2021.1926252

Bojczyk, K. E., Haverback, H. R., & Pae, H. K. (2018). Investigating maternal self-efficacy and home learning environment of families enrolled in head start. *Early Childhood Education Journal*, *46*(2), 169–178. https://doi.org/10.1007/s10643-017-0853-y

Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: From brain to education. *science*, *332*(6033), 1049–1053. https://doi.org/10.1126/science.1201536

Cahoon, A., Cassidy, T., Purpura, D., & Simms, V. (2021). Developing a rigorous measure of the pre-school home mathematics environment. *Journal of Numerical Cognition*, *7*(2), 172–194. https://doi.org/10.23668/psycharchives.4778

Carkoglu, C., Eason, S. H., & Purpura, D. (2023). Building the parent and child math anxiety network model from empirical evidence. *Child Development Perspectives*, *17*(3-4), 115–121. https://doi.org/10.1111/cdep.12484

Cordts, K. M. P., Wilson, A. C., & Riley, A. R. (2020). More than mental health: Parent physical health and early childhood behavior problems. *Journal of Developmental & Behavioral Pediatrics*, *41*(4), 265–271. https://doi.org/10.1097/DBP.0000000000000755

Costa, H. M., Outhwaite, L. A., & Van Herwegen, J. (2023). Early years practitioners' training, beliefs and practices concerning mathematics: implications for education and practice. *International Journal of Early Years Education*, 1–18. https://doi.org/10.1080/09669760.2023.2254822

Crawford, C., & Cribb, J. (2013). *Reading and maths skills at age 10 and earnings in later life: A brief analysis using the British cohort study*. Centre for Analysis of Youth Transitions.

Daucourt, M. C., Napoli, A. R., Quinn, J. M., Wood, S. G., & Hart, S. A. (2021). The home math environment and math achievement: A meta-analysis. *Psychological Bulletin*, *147*(6), 565. https://doi.org/10.1037/bul0000330

Davis-Kean, P. E., Domina, T., Kuhfeld, M., Ellis, A., & Gershoff, E. T. (2021). It matters how you start: Early numeracy mastery predicts high school math course-taking and college attendance. *Infant and Child Development*, *31*(2), e2281.

Dowker, A. (2021). Home numeracy and preschool children's mathematical development: Expanding home numeracy models to include parental attitudes and emotions. *Frontiers in Education*, *6*, 1–9. https://doi.org/10.3389/feduc.2021.575664

Duke, H. P., Allen, K. A., & Halverson, C. F. (1996). *A new scale for measuring parents' feelings of confidence and competence: The Parenting Self-Efficacy Scale* [Unpublished manuscript]. Athens: University of Georgia.

Eason, S. H., Scalise, N. R., Berkowitz, T., Ramani, G. B., & Levine, S. C. (2022). Widening the lens of family math engagement: A conceptual framework and systematic review. *Developmental Review*, *66*, 101046. https://doi.org/10.1016/j.dr.2022.101046

Elliott, L., Bachman, H. J., & Henry, D. A. (2020). Why and how parents promote math learning with their young children: A mixed-methods investigation. *Parenting*, *20*(2), 108–140. https://doi.org/10.1080/15295192.2019.1694830

Garcia, I. L., Fernald, L. C., Aboud, F. E., Otieno, R., Alu, E., & Luoto, J. E. (2022). Father involvement and early child development in a low-resource setting. *Social Science & Medicine*, *302*, 114933. https://doi.org/10.1016/j.socscimed.2022.114933

Ginsburg, H., & Baroody, A. (2003). *TEMA-3 examiners manual*. Pro-Ed.

Hoover-Dempsey, K. V., & Sandler, H. M. (1995). Parental involvement in children's education: Why does it make a difference? *Teachers College Record*, *97*(2), 310–331. https://doi.org/10.1177/016146819509700202

Hoover-Dempsey, K. V., & Sandler, H. M. (1997). Why do parents become involved in their children's education? *Review of Educational Research*, *67*(1), 3–42. https://doi.org/10.3102/00346543067001003

Hoover-Dempsey, K. V., & Sandler, H. M. (2005). *The social context of parental involvement: A path to enhanced achievement*. Final report for the office of educational research and improvement (grant number R305T010673). Washington, DC: U.S. Department of Education.

Hornburg, C. B., Borriello, G. A., Kung, M., Lin, J., Litkowski, E., Cosso, J., … Purpura, D. J. (2021). Next directions in measurement of the home mathematics environment: An international and interdisciplinary perspective. *Journal of Numerical Cognition*, *7*(2), 195. https://doi.org/10.5964/jnc.6143

Hunt, T. E., Clark-Carter, D., & Sheffield, D. (2011). The development and part validation of a UK scale for mathematics anxiety. *Journal of Psychoeducational Assessment*, *29*(5), 455–466. https://doi.org/10.1177/0734282910392892

James-Brabham, E., Loveridge, T., Sella, F., Wakeling, P., Carroll, D. J., & Blakey, E. (2023). How do socioeconomic attainment gaps in early mathematical ability arise? *Child Development*, *94*(6), 1550–1565. https://doi.org/10.1111/cdev.13947

Kalaycıoğlua, D. B. (2015). The influence of socioeconomic status, self-efficacy, and anxiety on mathematics achievement in England, Greece, Hong Kong, The Netherlands, Turkey, and the USA. *Educational Sciences: Theory and Practice*, *15*(5), 1391–1401.

Keating, M., Harmon, T., & Arnold, D. H. (2022). Relations between parental math beliefs and emergent math skills among preschoolers from low-income households. *Early Child Development and Care*, *192*(9), 1359–1367. https://doi.org/10.1080/03004430.2021.1881076

Kiss, A. J., & Vukovic, R. (2020). Exploring educational engagement for parents with math anxiety. *Psychology in the Schools*, *58*(2), 364–376. https://doi.org/10.1002/pits.22451

Leyva, D., Libertus, M. E., & McGregor, R. (2023). Math intervention targeting family routines increases parental math talk and math activities. *Journal of Applied Developmental Psychology*, *89*, 101595. https://doi.org/10.1016/j.appdev.2023.101595

Libertus, M. E. (2024). Parent-Focused interventions to support children's early math learning. *Current Directions in Psychological Science*, *33*(1), 3–9.

Malanchini, M., Rimfeld, K., Wang, Z., Petrill, S. A., Tucker-Drob, E. M., Plomin, R., & Kovas, Y. (2020). Genetic factors underlie the association between anxiety, attitudes and performance in mathematics. *Translational Psychiatry*, *10*(1), 12. https://doi.org/10.1038/s41398-020-0711-3

Maloney, E. A., Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2015). Intergenerational effects of parents' math anxiety on children's math achievement and anxiety. *Psychological Science*, *26*(9), 1480–1488. https://doi.org/10.1177/0956797615592630

Missall, K. N., Hojnoski, R. L., & Moreano, G. (2017). Parent–child mathematical interactions: Examining self-report and direct observation. *Early Child Development and Care*, *187*(12), 1896–1908. https://doi.org/10.1080/03004430.2016.1193731

Mues, A., Wirth, A., Birtwistle, E., & Niklas, F. (2022). Associations between children's numeracy competencies, mothers' and fathers' mathematical beliefs, and numeracy activities at home. *Frontiers in Psychology*, *13*, 835433. https://doi.org/10.3389/fpsyg.2022.835433

Mutaf-Yıldız, B., Sasanguie, D., De Smedt, B., & Reynvoet, B. (2020). Probing the relationship between home numeracy and children's mathematical skills: A systematic review. *Frontiers in Psychology*, *11*, 557630. https://doi.org/10.3389/fpsyg.2020.02074

Napoli, A. R., & Purpura, D. J. (2018). The home literacy and numeracy environment in preschool: Cross-domain relations of parent–child practices and child outcomes. *Journal of Experimental Child Psychology*, *166*, 581–603. https://doi.org/10.1016/j.jecp.2017.10.002

Organisation for Economic Co-operation and Development (OECD). (2020). *Early learning and child well-being: A study of five-year olds in England, Estonia, and the United States*. Available at: https://www.oecd.org/education/school/early-learning-and-child-well-being-3990407f-en.htm

Outhwaite, L. A., Aunio, P., Leung, J. K. Y., & Van Herwegen, J. (2024). *Measuring mathematical skills in early childhood: a systematic review of the psychometric properties of early maths assessments and screeners*. CEPEO Working Paper Series, (24-03).

Rogoff, B. (2003). *The cultural nature of human development*. Oxford University Press.

Silver, A. M., Elliott, L., & Libertus, M. E. (2021). When beliefs matter most: Examining children's math achievement in the context of parental math anxiety. *Journal of Experimental Child Psychology*, *201*, 104992. https://doi.org/10.1016/j.jecp.2020.104992

Silver, A. M., & Libertus, M. E. (2022). Environmental influences on mathematics performance in early childhood. *Nature Reviews Psychology*, *1*(7), 407–418. https://doi.org/10.1038/s44159-022-00061-z

Simmons, F. R., Soto-Calvo, E., Adams, A.-M., Francis, H. N., Patel, H., & Hartley, C. (2024). Longitudinal associations between parental mathematics anxiety and attitudes and young children's mathematics attainment. *Journal of Experimental Child Psychology*, *238*, 105779. https://doi.org/10.1016/j.jecp.2023.105779

Skene, K., O'Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C., & Ramchandani, P. G. (2022). Can guidance during play enhance children's learning and development in educational contexts? A systematic review and meta-analysis. *Child Development*, *93*(4), 1162–1180. https://doi.org/10.1111/cdev.13730

Skwarchuk, S. L., Sowinski, C., & LeFevre, J. A. (2014). Formal and informal home learning activities in relation to children's early numeracy and literacy skills: The development of a home numeracy model. *Journal of Experimental Child Psychology*, *121*, 63–84. https://doi.org/10.1016/j.jecp.2013.11.006

Sonnenschein, S., & Sun, S. (2017). Racial/ethnic differences in kindergartners' Reading and math skills: Parents' knowledge of children's development and home-based activities as mediators. *Infant and Child Development*, *26*(5), e2010. https://doi.org/10.1002/icd.2010

Stacy, S. T., Cartwright, M., Arwood, Z., Canfield, J. P., & Kloos, H. (2017). Addressing the math-practice gap in elementary school: Are tablets a feasible tool for informal math practice? *Frontiers in Psychology*, *8*, 214487. https://doi.org/10.3389/fpsyg.2017.00179

Susperreguy, M. I., Di Lonardo Burr, S., Xu, C., Douglas, H., & LeFevre, J. A. (2020). Children's home numeracy environment predicts growth of their early mathematical skills in kindergarten. *Child Development*, *91*(5), 1663–1680. https://doi.org/10.1111/cdev.13353

Swars, S. L., Daane, C. J., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics*, *106*(7), 306–315. https://doi.org/10.1111/j.1949-8594.2006.tb17921.x

Ten Braak, D., Lenes, R., Purpura, D. J., Schmitt, S. A., & Størksen, I. (2022). Why do early mathematics skills predict later mathematics and Reading achievement? The role of executive function. *Journal of Experimental Child Psychology*, *214*, 105306. https://doi.org/10.1016/j.jecp.2021.105306

Vandermaas-Peeler, M., Ferretti, L., & Loving, S. (2012). Playing the ladybug game: Parent guidance of young children's numeracy activities. *Early Child Development and Care*, *182*(10), 1289–1307. https://doi.org/10.1080/03004430.2011.609617

Van Rijen, E. H. M., Gasanova, N., Boonstra, A. M., & Huijding, J. (2014). Psychometric qualities of the short form of the self-efficacy for parenting tasks index-toddler scale. *Child Psychiatry & Human Development*, *45*, 443–455.

Vygotsky, L. S.. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Walker, J. M., Wilkins, A. S., Dallaire, J. R., Sandler, H. M., & Hoover-Dempsey, K. V. (2005). Parental involvement: Model revision through scale development. *The Elementary School Journal*, *106*(2), 85–104. https://doi.org/10.1086/499193

Watts, T. W., Clements, D. H., Sarama, J., Wolfe, C. B., Spitler, M. E., & Bailey, D. H. (2017). Does early mathematics intervention change the processes underlying children's learning? *Journal of Research on Educational Effectiveness*, *10*(1), 96–115. https://doi.org/10.1080/19345747.2016.1204640

Wu, J., Barger, M. M., Oh, D., & Pomerantz, E. M. (2022). Parents' daily involvement in children's math homework and activities during early elementary school. *Child Development*, *93*(5), 1347–1364.

Zhang, X., Hu, B. Y., Zou, X., & Ren, L. (2020). Parent–child number application activities predict children's math trajectories from preschool to primary school. *Journal of Educational Psychology*, *112*(8), 1521. https://doi.org/10.1037/edu0000457

Živković, M., Pellizzoni, S., Doz, E., Cuder, A., Mammarella, I., & Passolunghi, M. C. (2023). Math self-efficacy or anxiety? The role of emotional and motivational contribution in math performance. *Social Psychology of Education*, *26*(3), 579–601. https://doi.org/10.1007/s11218-023-09760-8

Appendix

Parental self-efficacy for maths and reading items. *Reversed coded items.

	Parental Self-Efficacy Maths items	Parental Self-Efficacy Reading items
1	I can always think of something to play with my child that involves helping to develop their maths skills.	I can always think of something to play with my child that involves helping to develop their reading skills.
2	I enjoy playing maths games with my child.	I enjoy reading with my child.
3*	I find it hard to know how I can add maths learning activities into daily routines and play with my child.	I find it hard to know how I can add reading activities into daily routines and play with my child at home.
4	I am able to get actively involved with my child when playing games that help develop their maths skills.	I am able to get actively involved with my child in reading activities that help develop their reading skills.
5	I have very little difficulty thinking of ways to help my child learn maths.	I have very little difficulty thinking of ways to help my child with learning to read.
6*	I really need to learn how I can help my child to develop their maths skills.	I really need to learn how I can help my child to develop their reading skills.
7	I think I spend an appropriate amount of time playing with my child to help develop their maths skills.	I think I spend an appropriate amount of time reading with my child to help develop their reading skills.
8	I feel motivated to help my child with their maths skills.	I feel motivated to help my child with their reading skills.
9	I know how to help my child do well in maths.	I know how to help my child do well in reading
10*	I don't know if I'm getting through to my child when I play maths games with them.	I don't know if I'm getting through to my child when I read with them.
11	I feel successful about my efforts to help my child develop their maths skills.	I feel successful about my efforts to help my child develop their reading skills.
12*	I don't know how to help my child learn maths.	I don't know how to help my child learn to read.
13	I make a significant difference in my child's maths development.	I make a significant difference in my child's reading development.
14	I believe that when I play maths games with my child, they understand maths concepts better.	I believe that when I read with my child, I am supporting their reading development.