The Role of Home Numeracy Experience to Improve Preschool Children's Early Math Competence in Addis Ababa

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Abstract

The formative years of a child's life are a critical phase of cognitive development; not only is it a time for the foundation but also a basis for all future academic and career successes. Home experience, as such, is the primary place for early mathematical concepts to be brought out in an informal as well as formal manner in which learning can occur. Thus, this research aims to assess the influence of home numeracy experience (HNE) on preschool children's early mathematics competence in Addis Ababa. A quantitative cross-sectional correlational design was used with 240 parent–child dyads recruited through multistage random sampling from government and private preschools. Parents completed questionnaires on home numeracy experiences, parental expectations, and attitudes toward mathematics. Children's early mathematics competence was assessed using the Early Mathematics Competence Test. Exploratory factor analysis provided rationale for the mixed dimensionality of the adapted Home Numeracy Experience survey, while hierarchical multiple regression was employed to understand the unique contribution of home numeracy practices (including, in addition to gender, specific school and socioeconomic status). Findings suggested that home numeracy experiences were able to explain a larger proportion of the variance in children's early mathematics competence than did demographic features. In particular, number skills activities and the use of mathematics in daily life were strong positive predictors of early mathematics competency, but parental expectations and attitudes did not explain any further variance once the effects of home numeracy practices were accounted for. These findings support sociocultural theories of learning by demonstrating the importance of meaningful parent–child mathematical interactions in promoting early mathematical development. The study contributes context-specific evidence from Ethiopia and highlights the importance of strengthening culturally relevant home numeracy practices to enhance school readiness and early mathematics achievement.

***Keywords*:** home numeracy experience, early math, preschool, and parental involvement.

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Introduction

Early numeracy, like counting, recognition of number concepts, and performing elementary arithmetic are all the basics of long-term mathematical competence (Soto-Calvo et al., 2019). Home Numeracy Experience (HNE) - parent-child engagement in numeracy activities- apart from having a significant effect on learning numeracy abilities (Kleemans et al., 2012) has also been a critical factor in later learning (Duncan et al., 2007). HNE as a learning environment encompasses the parents' resources, their activities, and their attitude towards mathematics; all these together promote the numeric development of the children (Kleemans et al., 2012; Kluczniok et al., 2013). These may include general activities like daily routines and specific learning activities like numeracy, literacy, or science-related ones (Skwarchuk et al., 2014).

Home activities focused on early numeracy skill development are very influential, as mentioned above, and can even be considered crucial. Formal teaching of numeracy is a type of teaching through which children are taught how to count, do calculations, and recognize different quantities (Skwarchuk et al., 2014), whereas informal activities encompass home-based daily routines and experiences such as shopping or cooking that connect children's learning activities in school to real life experiences (LeFevre et al., 2009). Research conducted by Blevins-Knabe et al. (2000) and Melhuish et al. (2008) revealed that the math-orientated skills of the children were improved by home-related numeracy experiences not only in school years but also much later. However, all mathematically inclined activities at home may not necessarily have a direct effect on being mathematically successful, hinting at the complex nature of such relationships (Blevins-Knabe et al., 2000; Bradley et al., 2001).

Studies showed divergent results regarding the effects of home numeracy early experiences on early math skills development. A few studies indicated that early home numeracy was a major determinant of children's math learning at early stages (Melhuish et al., 2008), whereas others found that home numeracy played little or no role (Blevins-Knabe et al., 2000). Differentiation on home numeracy contributions to math competence development is almost certainly indicative of various ways that families are thinking of numeracy, different socio-economic status (SES), school type (for example, private and government), and various cultural backgrounds of families and children participating in the studies (LeFevre et al., 2010). In this

vein, the current study investigated the role of home numeracy experiences, as measured through several home numeracy dimensions, on the early mathematical skills of very young children. Besides, the study also tried to investigate whether the level of children's numeracy expected by parents and their attitudes towards mathematics have a part to play in the evolution of early math competencies. Hence, beyond adding knowledge to the scanty empirical work on home numeracy in Ethiopia, the investigation is intended to give insights helpful in planning culturally appropriate, family-based numeracy activities, curriculum options, and research directions.

Problem Statement

As Ethiopia continues to focus on improving the quality of early childhood education, questions remain about how well the child's foundation of learning is addressed. In fact, many students enter primary education without strong experiences in reading and writing skills, let alone doing math (Tesfay, 2012; Tiruneh et al., 2021; Woldehanna et al., 2016; World Bank Group, 2022). These problems hint that the difficulties in math achievement are probably rooted in preschool years, a time when children should build the foundation for early literacy and numeracy. Therefore, it is important to identify the different factors that lead to a child's weak early skills in math, so that one can take corrective measures to eliminate the deficiency in later learning. According to some, home numeracy environment (HNE) significantly helps shape a child's early math knowledge and ability (Glewwe et al., 2017; Iyer et al., 2020). However, there is no consensus on the impact of early home numeracy on children's math skills later on. Little is known about relationships between home numeracy environment and mathematical competency of the children in the unique context of a developing country like Ethiopia. In most studies, no distinction is made between formal and informal number activities as well as types of schools that might play a role in the level of the child's learning outcome. Hence, the present research can be seen as the missing link between a child's math competence at an early age, their home numeracy (both formal and informal dimensions), and the role of parental expectations and attitudes towards early math development in a culture and socioeconomic framework of rural Ethiopia.

Research Questions

This research focused on generating locally relevant data regarding how home numeracy activities affect preschool mathematics skills in children in Ethiopia, which, in turn, would help us improve early math learning through our understanding of learning and learning outcomes.

Thus, the study attempted to answer the following research questions:

1. What is the status of early home numeracy experience among children in Addis Ababa?
2. Do the different aspects of early home numeracy significantly predict preschoolers' early math ability (taking into account parental expectations, math attitudes, gender and school type) in Addis?

Theoretical and Conceptual Framework

This study was informed by Vygotsky's Sociocultural Theory (Vygotsky, 1978), which assumes that children learn through social interactions with more knowledgeable others in culturally relevant situations. From this viewpoint, the home numeracy experience is a key mechanism that contributes to the early learning development of early mathematics knowledge and behavior.

One central aspect of sociocultural theory is the Zone of Proximal Development (ZPD), defined as the distance between what children can accomplish independently and what they can achieve with guidance and support from more knowledgeable individuals. In a home context, parents and caregivers use scaffolding activities to support children's learning of mathematics, counting things (for example), comparing amounts, and working through numerical problems from their work environment of doing everyday problem solving with a child. Children progressively internalize mathematical concepts and their potential uses, and use of the methods independently during guided interactions (Saxe et al., 2017; Skwarchuk et al., 2014).

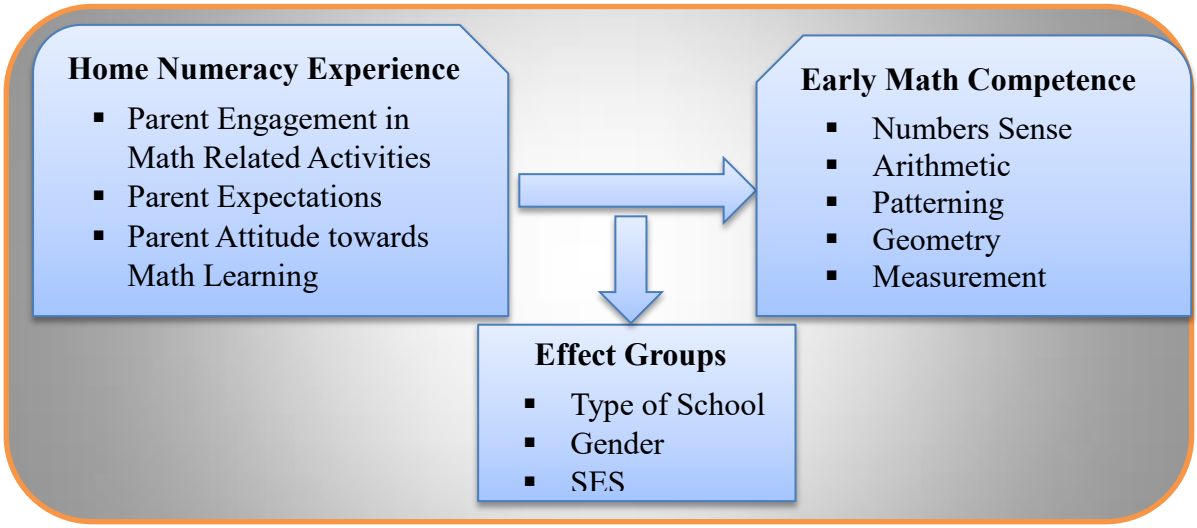
Sociocultural theory emphasizes the idea that learning is embedded in cultural practices and is mediated through language and social interaction. In many Ethiopian households, opportunities for mathematical learning emerge naturally through routine activities such as shopping, cooking, sharing household resources, and participating in market-related transactions. These everyday experiences provide meaningful contexts in which children can develop early

numeracy skills while engaging in culturally relevant practices (Mutaf-Yıldız et al., 2020; Susperreguy & Davis-Kean, 2016).

Based on this theoretical perspective, the present study conceptualizes home numeracy experiences as multidimensional learning opportunities encompassing formal numeracy activities, informal numeracy interactions, parental expectations regarding children's mathematical development, and parental attitudes toward mathematics. These factors are hypothesized to contribute to preschool children's early mathematics competence while operating within broader contextual influences, including socioeconomic status, school type, and child characteristics. Accordingly, the conceptual framework proposes that both the quality and frequency of home-based mathematical interactions support the development of foundational mathematical competencies during the preschool years.

Figure 1

Conceptual Framework of the Study



This research work draws upon the idea that parents' and children's home numeracy experience, such as numeracy activities and available learning resources, along with parent-related aspects like parents' beliefs and expectations, influence preschoolers' understanding of mathematics. These connections are investigated while taking into account the influence of the child's gender, type of school attended by the child, and the socioeconomic class of both parents. Also, home experience is expected to significantly contribute to the child's early numeracy

development through its physical features, as well as its interpersonal components, as per the model presented in Figure 1.

Methods

Study Design

The researchers used a quantitative cross-sectional correlation design to examine how home numeracy experiences influence the acquisition of early math skills among preschool children. Cross-sectional correlational designs involve collecting data at a single point in time and are appropriate for investigating naturally occurring relationships among variables without manipulating study conditions (Creswell & Creswell, 2017). The design was deemed appropriate because the main goal was to find out whether three dimensions of home numeracy experiences, parents' expectations, and caregiver attitudes towards mathematics directly correlated with the early mathematics competence of children, controlling for target demographic and contextual factors.

Population and Sample Size

The target population comprised all Upper Kindergarten (Level III) children attending the government and private preschools in Addis Ababa, Ethiopia, or around 67,708 children (Addis Ababa City Administration Education Bureau, 2023). The Upper Kindergarten children provided the focus of the study, as this stage is the last year of preschool education and is instrumental in building up the mathematical foundation before the child starts primary school.

The accessible population included Upper Kindergarten children going through the selected preschools and one person per child who knew the child from his/her home learning environment. A total of 240 parent–child dyads were recruited for participation using a multistage sampling strategy.

The adequacy of the number of participants was tested following established guidelines for multiple regression analysis. The minimum sample size, according to Green (1991), for testing individual predictors in multiple regression is $N \geq 50 + 8m$ ($m \approx$ number of predictors). Furthermore, Cohen's (1992) power analysis protocols state that between 118 and 150 participants makes for a considerable sample on medium effect sizes ($f^2 = .15$) at $\alpha = .05$ with statistical power of .80. As a result, the final sample size of 240 parent–child dyads surpassed the

recommended thresholds, which was sufficient to achieve sufficient statistical power for the planned analyses.

Sampling Technique

A multistage sampling technique was used to sample preschool children and their caregivers. Participants in the first stage were purposively sampled, and preschools were used as they have two characteristics that reflect different socio-economic contexts as the focus of the study. A total of 12 preschools (six preschools per category) were recruited to maximize balanced representation in school types while promoting the possibility of data collection. During the second stage, the Upper Kindergartens of each eligible preschool were stratified by gender, and a stratified random sample of 20 children (10 boys and 10 girls) was used, totaling 240 children in the final sample size. In the last step, a parent or a parent caregiver of each selected child was recruited by the community school to recruit the child, i.e., 240 parent–child pairs. This multi-stage strategy allowed representation of key subgroups (school type and gender) while yielding a relatively large enough sample size for multivariate analysis.

Measures

Early Math Competence Test (EMCT): Children's early mathematics competence was measured by a researcher-designed instrument, 25 items in length (Early Math Competence Test: EMCT). The research instrument was developed from a systematic test blueprint devised from the Ethiopian pre-primary curriculum (MoE, 2021) and empirical literature on early numeracy development. The blueprint outlined areas in early learning mathematics, such as: number recognition, object counting, pattern recognition, basic arithmetic operations, measurement, and shape recognition. Items were developed using such a framework systematically to cover content and relate them to the developmental process. The Early Math Competency (EMC) tests' content validity was examined by five experts in early childhood education to ensure that it was culturally and contextually appropriate. The Item-Level Content Validity Index (I-CVI) ranged from .80 to 1.00, and the overall Scale-Level Content Validity Index (S-CVI/Ave) was .96. It exceeded the recommended .80 value of excellent content coverage (Polit & Beck, 2006). A universal agreement index (S-CVI/UA) was also .80, with experts maintaining strong consensus. After a pilot study (n=40) was done to confirm item clarity, the instrument was administered to a full-sample population (N=240). The reliability analysis found a KR-20 coefficient of .76,

indicating sufficient internal consistency in measuring early numeracy and mathematical reasoning.

Home numeracy experiences were assessed using a 16-item scale (adapted from standardized instruments developed by LeFevre et al. (2009) and Skwarchuk et al. (2014)). The scale was initially divided into four theoretically derived domains: numeracy skills (direct teaching), number books (shared reading), number games (play-based activities), and number applications (everyday mathematics). Each domain consisted of 4 related items, and parents reported their level of engagement on a 5-point Likert-type scale from 0 (never) to 4 (almost daily).

Items were adapted through selection and adjustment to be culturally and contextually relevant to the Ethiopian preschool context, maintaining the concept and integrity of the content. The HNE survey was translated into Amharic and examined for content validity by a panel of 5 experts. The S-CVI/Ave of the survey was .88, with most items achieving an I-CVI ≥ .80.

To compare the construct validity of the adapted Home Numeracy Experience (HNE) Survey in the Ethiopian context, an exploratory factor analysis (EFA) was conducted on the 16 HNE items after initial data screening. Results showed satisfactory sampling adequacy (Kaiser–Meyer–Olkin [KMO] = .73) and a significant Bartlett's Test of Sphericity, χ^2 (120) = 1141.87, $p < .001$, confirming the correlation matrix was appropriate for factor analysis. The exploratory factor analysis revealed a rotational solution of four factors largely congruent with the theoretical aspects of the Home Numeracy Experience framework. The retained items showed primary factor loadings between .43 and .73, suggesting significant correlations between the items and their latent factors. However, for the retained items, the cross-loadings were not significant, except for an item (Application 2), which failed to have a salient loading on any factor. The factor solution was conceptually explainable and offered preliminary evidence that the adapted Home Numeracy Experience Survey was based on a multidimensional structure, in this case, a preschool-based approach in Ethiopia.

For later analyses, domain-specific subscale scores were calculated by averaging item responses from each factor, where higher scores indicated a higher frequency of participation in the corresponding home numeracy activities. The HNE survey overall showed acceptable internal consistency (Cronbach's $\alpha = .75$). Reliability was acceptable for Number Skills ($\alpha = .77$) and Number Games ($\alpha = .60$) subscales. Initial analyses indicated lower reliability for Number

Books (α = .29) and Number Applications (α = .42) subscales. Item-level diagnostics identified one poorly functioning item in each subscale, and their removal improved reliability to α = .58 and α = .54, respectively. Though these coefficients are modest, they are considered acceptable for exploratory research involving short, culturally adapted measures (Cortina, 1993; Hair et al., 2019; Nunnally & Bernstein, 1994). Both subscales maintained adequate factor loadings and were thus kept, as they indicate theoretically important aspects in the Home Numeracy Experience (LeFevre et al., 2009; Skwarchuk et al., 2014).

Parents' Expectations of Children's Numeracy Competencies: Parents' expectations of their children's mathematics skills were assessed on a 10-item scale based on several sources (e.g., LeFevre et al., 2009; Purpura, Baroody, & Lonigan, 2013). Parents reflected on their children's level of proficiency using a 3-point Likert scale (0 = cannot do this yet, 1 = can do this sometimes, 2 = can do it easily), encompassing skills including counting, writing numerals, simple arithmetic, shape recognition, and numerical application. An overall score of perceived numeracy competence was calculated by averaging all items. The scale also showed good internal consistency (α = .85), indicating reliable measurement of parents' expectations on children's numeracy skills.

Parental attitudes toward mathematics: Parental attitudes toward mathematics were measured by a 21-item scale adapted from Tapia (1996), consisting of 12 items associated with self-beliefs and 9 items with general attitudes. Responses were scored using a 5-point Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree), including dimensions such as math anxiety, enjoyment, and perceived usefulness of mathematics. A satisfactory internal consistency of the scale (α = .87) is evidence of high reliability in the survey of parental attitudes toward mathematics.

Socioeconomic Status (SES): The SES was operationalized as a combined index based on parents' levels of education, employment status, and household income. Each indicator was standardized (z-scores), and an individual SES composite score was calculated as the average of three standardized indicators. To guarantee the concept completeness of the SES construct, the composite score was computed only for subjects with complete data on all three SES indicators. Therefore, the SES composite score was provided to 216 individuals.

Data Analysis

Data analysis: Data were analyzed using SPSS Statistics Version 26. Descriptive statistics, including means and standard deviations, were calculated to summarize home numeracy experiences, parental factors, and children's early mathematics competence. Independent-samples t-tests were performed to compare mathematics competence by gender and type of preschool. The Pearson product–moment correlation coefficients were computed to examine connections between dimensions of home numeracy, parental expectations, and parent attitudes to mathematics.

To investigate how home numeracy experiences uniquely influence children's mathematics competence, hierarchical multiple regression analyses were performed. The predictor variables were put into theoretically relevant blocks. In the first model, demographic and contextual variables (child gender, school type, and socioeconomic status) were entered as control variables. In the second model, the four dimensions of home numeracy experience were added. Finally, in the final model, parental expectations and attitudes toward mathematics were measured, and their incremental explanatory capabilities beyond home numeracy practices and background variables were obtained.

Before applying the regression analyses, all statistical assumptions such as normality, linearity, homoscedasticity, independence of residuals, and multicollinearity, as well as any influential observations, were tested. Diagnostic results suggest that the assumptions were met satisfactorily. Effect sizes were calculated through Cohen's f^2, which assesses the practical significance of the incremental variance that can be accounted for by each block of predictors.

Results

Descriptive Statistics

Table 1

Descriptive Statistics of HNE, Parental Factors, and Early Math Competency (N = 240)

Domain	Minimum	Maximum	M	SD
Number Skills	1.17	4.00	3.01	0.693
Number Books	0.67	4.00	2.99	0.704
Games	0.67	4.00	2.90	0.772
Application	0.75	4.00	2.86	0.682
Parent's Expectation	0.20	2.00	1.70	0.362
Parent's Attitude towards Math	1.33	5.00	4.14	0.604
Early Math Competency Test	10.00	25.00	20.34	3.538

The descriptive statistics of all study variables, such as the domains Home Numeracy Experience (number skills, number books, games, and application activities), parental factors (expectations and attitudes toward mathematics), and children's early mathematics competency, are available in Table 1. Each domain was measured on a specified scale range, with possible scores ranging from the minimum to maximum values indicated in the same table.

Overall, the results show that parents reported moderately high engagement in number skills activities (M = 3.01, SD = 0.69) and number book activities (M = 2.99, SD = 0.70), with slightly lower engagement in games (M = 2.90, SD = 0.77) and application-based activities (M = 2.86, SD = 0.68). Parental expectations for children's mathematics performance were relatively high (M = 1.70, SD = 0.36), while attitudes toward mathematics were strongly positive (M = 4.14, SD = 0.60). Children's early mathematics competency scores indicated generally strong performance (M = 20.34, SD = 3.54), within a possible range of 10 to 25.

Table 2

Mean Differences in Early Mathematics Competence Scores across Gender

Child Gender	*n*	*M*	*SD*	*t (df)*	*p*	Mean Difference	95% CI
Boy	120	20.38	3.47				
Girl	120	20.31	3.62	0.146 (238)	.884	0.067	−0.835 - 0.968

Note. CI = Confidence Interval

As seen in Table 2, an independent-samples t-test found no statistically significant difference in early mathematics competence between boys and girls, t (238) = 0.15, p = .884. Boys (M = 20.38, SD = 3.47) and girls (M = 20.31, SD = 3.62) did not differ significantly, with a mean difference of 0.07, 95% CI [−0.84, 0.97]. In this study, gender was not associated with early mathematics competence among preschool children.

Table 3

Mean Differences in Early Mathematics Competence Scores by Preschool Type

Group	*n*	*M*	*SD*	*t (238)*	*p*	Mean Difference	95% CI
Government	120	17.30	2.14				
Private	120	23.38	1.39	-26.17	.001	-6.08	[-6.54, -5.63]

Note. CI = Confidence Interval.

As seen in Table 3, an independent-samples t-test found a statistically significant difference in early mathematics competencies between government and private preschoolers, t (238) = -26.17, p < .001. Private preschoolers (M = 23.38, SD = 1.39) differed significantly from government preschoolers (M = 17.30, SD = 2.14), and the difference was -6.08 (95%). In this study, private preschool children were found to have higher early math competencies than government preschool children.

Correlation Analysis

***Table 4**: Pearson Correlations among Early Math Competence and Home Numeracy Variables*

	1	2	3	4	5	6	7
1. EMCT Score	1						
2. Number Skill	.723**	1					
3. Number Book	.174**	.163*	1				
4. Number Game	0.014	0.001	.526**	1			
5. Number Application	.666**	.579**	.277**	.173**	1		
6. Parent Expectation	.353**	.432**	.252**	0.118	.397**	1	
7. Parent Attitude	.266**	.320**	.223*	0.091*	.319**	.450**	1

***Note**: EMCT - Early Math Competence Test Score; p* < .05*, **p** < .01** (two-tailed).

Table 4 presents the intercorrelations among children's early mathematics competence, dimensions of home numeracy experience, parental expectations, and parental attitudes toward mathematics. Results showed that early mathematics competence was strongly and positively correlated with number skill activities (r = .723, p < .01) and number application activities (r = .666, p < .01). In contrast. However, the correlation between number book activities and early mathematics competence was statistically significant (r = .174, p < .01), but the magnitude of the relationship was relatively weak. No statistically significant relationship was observed between number game activities and early mathematics competence (r = .014, p > .05).

Furthermore, early mathematics competence demonstrated significant positive correlations with parental expectations (r = .353, p < .01) and parental attitudes toward mathematics (r = .266, p < .01). Overall, the findings suggest that structured and applied numeracy activities are more strongly associated with preschool children's mathematical competence than informal game-related activities.

Regression Analysis

Prior to conducting the hierarchical multiple regression analysis, all relevant statistical assumptions were assessed and found to be satisfactorily met. Multicollinearity was not a

concern, as tolerance values ranged from .409 to .948 and Variance Inflation Factor (VIF) values ranged from 1.06 to 2.44, well below the recommended threshold of 10. The Durbin–Watson statistic of 1.72 indicated independence of residuals. Examination of standardized residual histograms and normal P–P plots suggested that the residuals were approximately normally distributed. In addition, visual inspection of the scatterplot of standardized residuals against standardized predicted values indicated no serious violation of the homoscedasticity assumption. Although the maximum Mahalanobis distance (29.49) suggested the presence of a small number of multivariate outliers, the maximum Cook's distance (.184) was substantially below the critical value of 1.0, indicating that no individual case exerted undue influence on the regression model. Overall, the data met the assumptions required for hierarchical multiple regression analysis.

Table 5

Model Summary for Hierarchical Multiple Regression Predicting Preschool Children's Early Mathematics Competence (N=216)

Model	R	R^2	Adjusted R^2	ΔR^2	ΔF	df1	df2	*p* (ΔF)
1	.858[a]	.736	.732	.736	196.945	3	212	.000
2	.916[b]	.838	.833	.102	32.863	4	208	.000
3	.916[c]	.838	.831	.000	0.08	2	206	.881

a. Predictors: (Constant), SES Composite, Preschool Type, Child Gender

b. Predictors: (Constant), SES Composite, Preschool Type, Child Gender, Game, Number Book, Application, Number Skill

c. Predictors: (Constant), SES Composite, Preschool Type, Child Gender, Game, Number Book, Application, Number Skill, Attitude, Expectation

d. Dependent Variable: Early Mathematics Competence

Hierarchical multiple regression analysis was performed to investigate the contribution of experiences with home numeracy to preschool children's early mathematics competence after controlling for child gender, school type, and socioeconomic status (SES) as observed in Table 5. The assumptions of multiple regression prior to the analysis were analyzed and found to be sound. The Durbin–Watson statistic (1.68) showed that the residuals were independent and

showed no evidence of major multicollinearity, normality, linearity, or homoscedasticity violations.

In Model 1, the control variables (child gender, school type, and SES) accounted for a statistically significant 73.6% of the variance in early mathematics competence ($R^2 = .736$; Adjusted $R^2 = .732$; $F(3, 212) = 196.95$, $p < .001$). This finding indicates that demographic and socioeconomic characteristics of children had a substantial effect upon the range of mathematics competence.

In Model 2, the four dimensions of Home Numeracy Experience (Number Skills, Number Books, Number Applications, and Number Games) were entered after controlling for background variables. This model explained 83.8% of the variance in children's early mathematics competence, $R^2 = .838$, Adjusted $R^2 = .833$. Including the home numeracy variables results in $\Delta R^2 = .102$, $\Delta F (4, 208) = 32.86$, $p < .001$. Thus, home numeracy experiences accounted for an additional 10.2% of the variance in early mathematics competence beyond the effects of gender, school type, and SES, demonstrating their substantial incremental contribution.

Model 3 included parental attitudes towards mathematics addition as well as parental expectations to determine whether they explained variance beyond demographic measures and home numeracy experiences. Finally, the last model was statistically significant overall ($R^2 = .838$, Adjusted $R^2 = .831$). However, adding parental attitudes and parental expectations did not lead to a significant gain to the model, $\Delta R^2 < 0.001$, $\Delta F (2, 206) = 0.13$, $p = .881$. Finally, while parental attitudes and expectations were positively related to children's mathematics competence at the bivariate level, they showed no additional unique variance when controlling for factors such as home numeracy experiences and background characteristics.

All in all, the hierarchical regression results indicate that home numeracy experiences are a valuable contribution to the early mathematics competence of preschoolers across demographic and socioeconomic domains. Comparatively, parental attitudes with respect to mathematics and their expectations of parents were not found to retain significant incremental predictive value once home numeracy practices were taken into account.

Table 6

Regression Coefficients Predicting Preschool Children's Early Math Competence

Model	Predictor	B	SE B	β	t	p	VIF
1	(Constant)	17.670	0.417	_	42.411	0.000	_
1	School Type	6.019	0.250	0.850	24.087	0.000	1.000
	Child Gender	-0.242	0.252	-0.034	-0.961	0.338	0.983
	SES_Composite2	0.640	0.218	0.104	2.932	0.004	0.983
2	(Constant)	14.039	0.774	_	18.129	0.000	_
	School Type	3.904	0.293	0.551	13.343	0.000	0.456
	Child Gender	-0.209	0.200	-0.030	-1.048	0.296	0.979
2	SES_Composite2	0.550	0.175	0.090	3.146	0.002	0.958
	Number Skill	1.082	0.209	0.218	5.169	0.000	0.438
	Number Game	0.212	0.157	0.046	1.352	0.178	0.665
	NumBook_2	-0.624	0.141	-0.152	-4.427	0.000	0.662
	NumAPP_2	0.980	0.159	0.236	6.182	0.000	0.534
3	(Constant)	13.823	0.929	_	14.872	0.000	_
	School Type	3.903	0.294	0.551	13.264	0.000	0.454
	Child Gender	-0.200	0.203	-0.028	-0.987	0.325	0.953
3	SES_Composite2	0.558	0.177	0.091	3.156	0.002	0.944
	Number Skill	1.076	0.217	0.217	4.951	0.000	0.409
	Number Game	0.214	0.159	0.047	1.349	0.179	0.657
	Number Book_2	-0.634	0.143	-0.154	-4.429	0.000	0.649
	Number APPlication_2	0.975	0.164	0.235	5.956	0.000	0.505
	Parent Expectation	-0.085	0.340	-0.009	-0.250	0.803	0.662
	Parent Attitude	0.096	0.194	0.016	0.496	0.620	0.725

Note. *B = unstandardized coefficient; SE = standard error; β = standardized coefficient; VIF = variance inflation factor. Dependent variable = Early Mathematics Competence Test (EMCT) score.*

As shown in Table 6, Model 1 investigated the impact of the control variables on early mathematics competence of preschoolers. School type (B = 6.02, β = .85, p < .001) and socioeconomic status (SES; B = 0.64, β = .10, p = .004) were significant positive predictors of early mathematics competence, whereas child gender was not statistically significant (B = −0.24, β = −.03, p = .338).

Following controlling for such demographic factors, the four Home Numeracy Experience (HNE) dimensions were entered into Model 2. Number Skills (B = 1.08, β = .22, p < .001) and Number Applications (B = 0.98, β = .24, p < .001) appeared as significant positive predictors for early mathematics competence, which suggests that more activities involving number skills and number applications were associated with higher mathematics competence. Number Games did not predict mathematics competence in children (B = 0.21, β = 0.05, p = .178). The Number Books domain generated a statistically significant inverse regression coefficient (B = −0.62, β = −.15, p < .001). Given that this coefficient has been estimated while accounting for other home numeracy dimensions, it is likely indicative of a suppression effect due to a shared variance between predictors as opposed to a direct inverse association with shared number book reading and children's mathematics competence. School type (B = 3.90, β = .55, p < .001) and SES (B = 0.55, β = .09, p = .002) remained significant positive predictors after adjusting for home numeracy experiences.

In Model 3, parental expectations and parental attitudes toward mathematics were considered to determine whether they accounted for additional variance in children's mathematics competence over demographic characteristics and home numeracy experiences. Neither parental expectations (B = −0.09, β = −.01, p = .803) nor parental attitudes (B = 0.10, β = .02, p = .620) significantly predicted early mathematics competence. The effects of School Type (B = 3.90, β = .55, p < .001), SES (B = 0.56, β = .09, p = .002), Number Skills (B = 1.08, β = .22, p < .001), Number Books (B = −0.63, β = −.15, p < .001), and Number Applications (B = 0.98, β = .24, p < .001) remained statistically significant, whereas Child Gender and Number Games continued to be non-significant.

Collinearity diagnostics showed no problem with multicollinearity. Tolerance values ranged from .41 to .98, and all variance inflation factor (VIF) values were between 1.02 and 2.44, low compared with a benchmark threshold of 5.0. In general, the results show that not only

did school type and socioeconomic status, and specific representations of home numeracy experiences—i.e., Number Skills and Number Applications—contributed significant unique contributions to early mathematics competency in preschool children once demographic characteristics were held constant. While the Number Books subscale showed a significant negative coefficient of regression, it should be viewed cautiously, as this is probably a suppression effect induced by the co-occurrence of correlated home numeracy dimensions in the regression model. By contrast, parental expectations and parental attitudes to mathematics did not account for further variance beyond that reflected in demographic characteristics and home numeracy experiences.

Discussion

The current research explored the relationship of home numeracy experience (HNE) with preschool children's early mathematics competence in Addis Ababa, Ethiopia. The study investigated to what extent various dimensions of home numeracy activities, parental expectations and parental attitudes about mathematics predict children's early math competence, controlling for child gender, school type and socioeconomic status. The results shed light on how home-based numeracy practices support early mathematical development in Ethiopia.

Home Numeracy Experience of Preschool Children.

This focus has been supplemented with key research questions to determine the development of home numeracy experience in preschool children in Addis Ababa. The findings show families to be moderately active at-home numeracy activities, and the children in the preschool, such as kindergarten, seemed exposed to a range of mathematical experiences, but their exposure varied according to the dimensions of home numeracy. This indicates that while Ethiopian parents often give significant opportunities for mathematical learning in day-to-day contexts, they may not regularly implement approaches that foster the development of early numeracy skills in a systematic manner.

Such findings align with recent understandings of the home numeracy context; these scholars advocate for the importance of children's mathematical learning occurring within the context of both formal experiences (e.g., counting, number recognition) and informal events woven into daily activities — grocery shopping, cooking, games (LeFevre et al., 2009;

Skwarchuk et al., 2014). Societally, these common interactions serve as valuable sites in which parents guide children's emerging mathematical knowledge in a scaffolde manner, in terms of participation and problem solving together (Vygotsky, 1978). Indeed, given the average degree of home numeracy input for this study, there are opportunities where the Ethiopian families have support systems in place to encourage children to work with their mathematics; in some instances, children may benefit from more awareness of developmentally appropriate numeracy experiences.

Results also indicated an impact of the contexts of home numeracy experiences. Differences in parental educational resources, socioeconomic status, and access to numeracy resources may explain varying frequencies and fashions of home-based mathematical interactions. The home learning environment has also been shown to be influenced by family resources and parents (Melhuish et al., 2008; Kluczniok et al., 2013). Therefore, interventions that offer parents practical guidance for embedding mathematics in everyday family routines may reinforce early opportunities for learning mathematics for children.

The Association between Home Numeracy Experience and Early Mathematics Competence.

The second research question was 'Did home numeracy experiences have an association with preschool children's mathematics competence?' It was found that home numeracy experiences predicted children's mathematics competence and accounted for an additional level of variation (excluded from the regression analyses that investigated child gender, type of school attending, and socioeconomic status). Specifically, number skills activities and the application of mathematics in daily life were found to be important predictors of early mathematics competence, highlighting the role of parent–child involvement in mathematical learning.

These results support the Home Numeracy Model from LeFevre et al. (2009) and elaborated by Skwarchuk et al. (2014), who argue that children's mathematical competence is fostered through repeated engagement in meaningful numeracy challenges in the home. They corroborate emerging meta-analytic data showing that the home mathematics environment has a significant effect on children's mathematical success, regardless of ethnic background (Daucourt et al., 2021). Based on Vygotsky's (1978) sociocultural theory, how parent–child numeracy interactions serve as scaffolds for children to move from assisted to independent mathematical thinking is examined. Counting household things, comparing numbers, numerical recognition,

and the identification and application of numerals and concepts from math practice in everyday household scenarios all help children learn early math to be able to internalize the building blocks of how to approach math and apply basic math knowledge while learning.

Paradoxically, parental expectations and parental attitudes were found to explain no further variation in children's mathematics competence post-incident, after their home numeracy experiences. These results indicate that parents' beliefs alone may not be enough to improve of children's mathematical development, except when the belief is used and connected to routine and meaningful numeracy activities. This is consistent with ecological views of child development which recognize that child learning is more linked to the nature of proximal processes that take place in the home than what parents think in isolation (Bronfenbrenner & Morris, 2007). In a similar vein, Susperreguy and Davis-Kean (2016) suggested that parental beliefs affect children's mathematical learning through the frequency and quality of interactions parents have with children in mathematical interactions.

However, it should be noted that there is a significant negative regression coefficient for the Number Books subscale. This effect was not observed until after adjustment for the other home numeracy dimensions, and it likely reflects statistical dampening due to the shared variance between correlated predictors, rather than the finding that shared mathematical book reading influences children's mathematics competence negatively. Previous research shows positive associations between mathematically enriched shared reading and children's mathematical language and conceptual understanding (LeFevre et al., 2010; Soto-Calvo et al., 2019). This suggests a need for future research to address this relationship with further refinement of the measures and longitudinal design methods to identify whether numeracy-related book reading uniquely contributes to children's mathematical competence in Ethiopian preschool contexts.

In summary, the results indicate that home numeracy experiences serve as a particularly salient developmental environment to support preschool children in developing early mathematics knowledge. They are also in line with the burgeoning international literature in providing evidence from Ethiopia, for which little is known about the home numeracy environment. The results also indicate that education policies and early childhood interventions can be used to help parents include meaningful mathematical experiences in their day-to-day as

parents, and so be of use in preparing children for school and in equitable early mathematics achievement.

Limitations of the Study

There are several limitations that should be taken into account when interpreting the results of the current study. First, to avoid making causal inferences regarding home numeracy experiences and preschool children's early mathematics competence, this study is cross-sectional. Secondly, parental self-report questions introduced social desirability and recall bias into the analysis. Third, although the overall Home Numeracy Experience (HNE) survey demonstrated satisfactory reliability, the refined Number Books (Cronbach's $\alpha = .58$) and Number Applications (Cronbach's $\alpha = .54$) subscales showed only modest internal consistency, possibly dampening the relationships we observed because the measurements lacked validity. However, these subscales are considered because they show acceptable factor loadings in exploratory factor testing and belong to theoretically significant dimensions of the Home Numeracy Experience framework (LeFevre et al., 2009; Skwarchuk et al., 2014). As a result, findings pertaining to these dimensions pose a concern, and future longitudinal studies should help refine and validate these dimensions employing culturally relevant and multi-method assessment methods.

Conclusion

This study investigated the effects of home numeracy experiences on preschool children's early mathematics competence in Addis Ababa. The results suggested that parents most frequently involved their children with direct number skill and number book activities, indicating a shift towards more explicit numeracy tasks to achieve structured numeracy at home. In contrast, home numeracy experience dimensions were differentially correlated with children's mathematics competency.

Taking parental expectations into account, direct number skill and applied numeracy experiences were found to be significant predictors of early mathematics competence among preschool children, whereas number book activities and numeracy games were unrelated to mathematics competence. Further, parental expectations and attitudes had a positive relationship with mathematics competence of children, but there is no additional variance beyond the home

numeracy practices. There were no obvious gender differences, although, children attending private preschools had higher level of mathematics accomplishment compared to government preschool.

Taken as a whole, the results of this study suggest that meaningful numeracy interactions in the home are important, particularly involving direct numeration activities and applied numeracy experiences that can be integrated into everyday life and therefore contribute positively to the children's early mathematics competence in Addis Ababa preschool. Furthermore, the findings also found that structured and applied home numeracy practices are more successful than informal game-related activities in developing children's mathematical competence. Even though home numeracy practices and background variables were controlled for, parents' expectations and attitudes toward mathematics and their relationship with children's mathematics competence were positively associated, but the relationship was not statistically significant. To promote early mathematics learning and educational equity in Ethiopia, the study highlights the need to support culturally relevant home numeracy experiences. Longitudinal and multi-method studies are needed to measure the long-term contribution of home numeracy experiences to children's mathematical development.

Declaration of Conflicting Interests

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