

Exploring the Role of Parental Factors as Determinants of Early Numeracy Skills in Indonesian Preschool Children

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Abstract

Research on parental roles in explaining the early numeracy in Indonesian children is relatively limited, leaving the understanding of this specific topic inconclusive. This study aims to address this research gap by investigating the links between several parental factors i.e., numeracy activities with children, parent expectation and parent judgment, and early numeracy in Indonesian preschool children. A total of 84 preschool children (45% girls and 55% boys; mean age = 59.56 months, SD = 5.29) and their parents participated in two measurement points. The children underwent early numeracy tests at both points (the Early Numeracy Test–Revised with 45 items per parallel version; $\alpha = .90$ for Version A and $\alpha = .88$ for Version B), while parents completed questionnaires regarding home numeracy activities (5 items, $\alpha = .82$), their expectations (6 items, $\alpha = .95$), and judgments about their children's early numeracy skills (2 items). The first measure of early numeracy was utilized as a control variable for the second early numeracy that was treated as a dependent variable in a hierarchical regression. Parent judgment was significantly correlated with early numeracy ($r = .53$, $p < .01$) and remained a significant concurrent correlate after controlling for prior early numeracy ($b = 0.31$, $SE = 0.10$, $p = .002$), supporting Hypothesis 3. Home numeracy activities and parent expectations, by contrast, were not significantly related to early numeracy, so Hypotheses 1 and 2 were not supported. These findings suggest that parents' judgments may provide complementary information about young children's numeracy competence.

Keywords: early numeracy, home numeracy activities, parent expectation, parent judgment

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Introduction

Over the past two decades, a significant concern in Indonesian education is early numeracy, perceived as a key determinant for the country's underperformance in the Programme for International Student Assessment (PISA) 2018 (OECD, 2019). Meanwhile, Indonesia's scores on the Program for International Student Assessment (PISA) consistently show that Indonesian students (aged 15) score lower than the OECD (Organization for Economic Co-operation and Development) average in mathematics (OECD, 2010, 2013, 2016, 2019, 2023). Indonesian students achieved an average mathematics score of 379 in 2018 and 366 in 2022, compared with OECD averages of 489 and 472, respectively (OECD, 2019, 2023). Moreover, in 2022, only 18% of Indonesian students attained at least Level 2 proficiency in mathematics, the baseline level required to demonstrate fundamental mathematical competence, compared with the OECD average of 69%, while only a negligible proportion reached the highest proficiency levels (Levels 5-6) (OECD, 2023). These findings underscore the persistent challenges in mathematics achievement and highlight the need to strengthen the foundations of mathematical learning from early childhood.

Although significant attention has been devoted to mathematical competence in elementary and secondary schools, the foundations of mathematics, e.g., early numeracy, are reported to be one of the most predictive factors of mathematical competence in subsequent years (Duncan, 2007). Notably, the meta-analysis demonstrated that the benefits of early numeracy extend beyond the acquisition of basic mathematical skills, exerting a cumulative (i.e., snowball) effect on later mathematical development, including word-problem solving. These findings suggest that strengthening early numeracy is essential not only for school readiness but also for long-term mathematical achievement (Liu et al., 2025). Addressing this concern, there has been a concerted effort through extensive educational campaigns highlighting the importance of early childhood education (Dhieni et al., 2020). According to the Decree of the Head of the Agency for Standards, Curriculum, and Educational Assessment, Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia (2024) on the Learning Outcomes for Early Childhood, Primary, and Secondary Education under the *Merdeka Curriculum*, numeracy is one of the core learning outcomes for early childhood education. It encompasses children's ability to understand numerical

relationships, identify patterns, recognize shapes and object characteristics, classify objects, and develop an awareness of time and the relationships among concrete objects. Achieving these learning outcomes requires learning opportunities beyond preschool, with the home serving as children's earliest and most consistent context for numeracy development. Indeed, the home numeracy environment plays a pivotal role in early numeracy, often exceeding the influence of preschool attendance on early competencies (Anders et al, 2013).

Several studies point out the importance of the home numeracy environment to the early numeracy development, which includes home numeracy activities (Mutaf-Yıldız et al., 2020; Susperreguy et al; 2020), parental expectations (Ayala et al, 2026), and parental judgments (Saleh et al, 2026). Meanwhile, research on home numeracy environments has largely focused on Western and East Asian contexts. Evidence on how parents in Indonesia implement home numeracy activities remains limited, particularly among low- to mixed-socioeconomic parents where family resources and educational opportunities may differ from those reported in Western and East Asian contexts. It may represent a distinct sociocultural context with different family values, educational expectations, educational resources, and caregiving practices. Parental scaffolding in numeracy-related stimulation does not arise spontaneously; rather, it is shaped by family structures, such as socioeconomic status (SES) (Elliott & Bachman, 2018), and by broader contextual factors, including the values, norms, and cultural practices in which families are embedded (Jordan et al., 2009; Anders, 2013). Such cultural differences may contribute to variations in parental beliefs and expectations (Huntsinger et al., 1997), which in turn influence everyday parent-child interactions (Goldenberg et al., 2001). To offer specific recommendations for parents and teachers to support early numeracy development, especially among low to mixed-socioeconomic parents, it is imperative to have insights into the context of early numeracy in Indonesia. Furthermore, this study seeks to untangle the relationship between early numeracy and parental factors, including the home numeracy activities employed to support their children's learning, as well as the expectations and judgments they hold regarding their children's early numeracy skills.

Early numeracy skills, defined as children's ability to comprehend quantities, understand their relationships and map them onto number words and numerals (Douglas et al., 2021), develop before formal education begins (Passolunghi & Lanfranchi, 2011). Similar to mathematics, which encompasses multiple dimensions (see, for example, NEPS working

paper, Schnittjer et al., 2020), early numeracy involves various skills, including recognizing number symbols, comparing numerical magnitudes, identifying quantities, manipulating quantities (addition and subtraction), verbal counting, and discerning number patterns (Raghubar & Barnes, 2017). Literature classifies these skills into non-symbolic, symbolic numbers, and advanced problem-solving ability with symbolic numbers (Zippert & Ramani, 2016). Non-symbolic number ability involves manipulating and transforming numbers on objects without using symbols, as well as comparing the magnitudes of collections of items. This ability is particularly crucial for children under the age of 6, as it strongly correlates with general mathematics ability (Fazio et al., 2014). Early symbolic number skills encompass learning the count sequence, understanding the numerical meaning of number phrases (e.g., "five" and "one"), and recognizing Arabic numerals (e.g., "5" and "1"). When a child grasp the cardinality principle, they are considered to have a working knowledge of symbols (Raghubar & Barnes, 2017). Children's advanced ability to solve symbolic number problems includes applying foundational knowledge to solve more complex problems, such as determining which of two number words or written numerals is larger and solving the sum of two numbers (Zippert & Ramani, 2016).

Research in early childhood has documented that the development of early numeracy is linked to several factors, including numeracy-related activities, gender, maternal education, and parent native language status (Anders et al., 2013; Anders et al., 2012). Using a longitudinal German sample, Anders et al. (2012) reported that maternal education significantly influences initial early numeracy but not later growth in this skill. In contrast, gender, parental native language status, and socioeconomic status explained significant variance in both intercept (initial early numeracy) and slope (growth of early numeracy).

Literature Review

Home Numeracy Activities

Home numeracy activities encompass all joint parent-child activities designed to support the early numeracy skills of children. According to the home numeracy model (Skwarchuk

et al., 2014), early numeracy activities can be classified as formal and informal numeracy activities. Formal numeracy activities involve shared experiences in which parents intentionally teach children about numbers, quantity, or arithmetic to enhance numeracy knowledge. On the other hand, informal numeracy activities are those shared activities where teaching about numbers, quantity, or arithmetic is not the primary purpose but may occur incidentally (Skwarchuk et al., 2014, p. 65). Examples of informal numeracy activities include spatial processing, carpentry, and playing number board games (Skwarchuk et al., 2014).

Previous studies have documented the relationships of both formal and informal early home numeracy activities with a wide array of academic outcomes, such as mathematics achievement and mathematics dispositions. A study by LeFevre et al. (2010) found that early numerical activities, particularly those involving direct experiences with numbers or mathematical content, were significantly positively linked to numeracy skills among 100 Greek and 104 Canadian five-year-old children.

Furthermore, using a sample of Greek children, Manolitsis et al. (2013) discovered that both parent numeracy and literacy teaching predict early math skills, consistent with results from a German study (Anders et al., 2012). This underscores the importance of literacy for the acquisition of early numeracy, which is inherently strongly related to language competence (Abedi & Lord, 2001; Novita et al., 2023). Anders et al. (2012) found that the initial early numeracy of German children is strongly linked to the quality of the home numeracy environment in the first year of preschool and remains consistent at later ages. However, their study did not identify any significant contribution of home numeracy environments to the growth of early numeracy, which appears to be associated with preschool process quality (Anders et al., 2012). A study of Chilean children from diverse socioeconomic backgrounds found that parents who provided frequent operational numeracy activities, such as learning simple sums at pre-kindergarten, are likely to have children with good arithmetic performance and growth in non-symbolic and symbolic number comparison at the end of kindergarten, highlighting the persistent link between the home numeracy environment and children's early numeracy (Susperreguy et al., 2020). However, literature have also documented learning activities at home may not have significant relationship with cognitive outcomes of children from low socioeconomic background (Cheung et al., 2018),

suggesting that a unique interactional pattern between activities at home and socioeconomic status of parent.

In conclusion, the relationship between the home numeracy environment and early numeracy appears more complex than it sounds, involving various interrelated factors such as other cognitive competencies as well as other contexts and cultures. Specifically in the Asian context, studies in early childhood have yielded interesting results (also see Cheung et al., 2021). First, the frequency and number of learning activities are associated with both early literacy and numeracy skills (Cheung et al., 2020; Queen Rania Foundation, 2017). Second, fathers and mothers seem to play different roles in predicting mathematics skills; while father's involvement in number game activities makes a unique contribution to children's number skills, mother's involvement plays no significant role in this respect (Liu et al., 2019). Third, the frequency of engaging preschool children in learning activities, such as playing word games and playing with number toys, is higher in Kazakhstan and Korea than in Singapore, Indonesia, Japan, and Jordan; suggesting no relationship between gross domestic product and the frequency of learning activities. However, most of the studies were conducted using a cross-sectional design, and to our knowledge, research analyzing predictors for early numeracy in Indonesia does not exist yet.

Parent Expectation

Parents' expectations play a significant role in shaping the educational outcomes of their children's upbringing (Briley et al., 2014). Preschool children may not yet be capable of forming their own educational expectations, as discussed by Hoenig (2019), based on their parents' expectations. However, literature in early childhood has documented that parents' beliefs and attitudes toward their children's learning and development are likely to influence their behavior in fostering their children's skills at home (Cheng, 2001). For example, a mother's attitude toward mathematics indirectly influenced children's early numeracy through their perceptions of children as active learners, while a mother's constructivist views of mathematics had a direct relationship with early numeracy (Lee & Kim, 2016). It appears that the mechanism underlying the relationship between parent expectations and early numeracy lies in parents' behavior, including the activities they engage in at home to support

their children's learning (Douglas et al., 2021). Chilean mothers and fathers with high expectations for their children engage in more frequent advanced numeracy practices than those with low expectations (del Río et al., 2017). Similar results were found by Seger et al. (2015), who used both parent expectations and numeracy activities as indicators for home numeracy environments for Dutch children.

Research on parent expectations in early childhood is relatively limited compared to that in middle childhood or adolescence (Briley et al., 2014; Loughlin-Presnal & Bierman, 2017; Ma, 2001). Perhaps, during early childhood, parents do not have clear guidelines to form specific expectations about their children. As mentioned in the home numeracy activities section, activities supporting early numeracy are rarely formal, making it challenging to form judgments about further skills. Nevertheless, it is important to investigate whether parent expectations may play a crucial role in the early numeracy of children, primarily for providing parent recommendations to best support their children.

To our knowledge, no prior research has examined the role of parent expectations in explaining the early numeracy of Indonesian children. Generally, in Asian settings, Cheung et al. (2021) suggested that Asian parents with preschool children acknowledge the importance of learning about numeracy, such as counting objects from one to nine, understanding quantity, and exploring geometry and space, such as playing with geometric shapes, prior to formal schooling. However, there is no clear tendency regarding whether Asian parents prefer to engage their children in literacy or numeracy activities due to the very high heterogeneity in findings across countries.

Parent Judgments

Parent judgments refer to parents' assessments of their children's competence. According to Parker (2021), these judgments may determine parents' willingness to invest in their children's education, influence the ways in which they support their children's learning (Gunderson et al., 2012), and impact their children's self-concept (Pesu et al., 2016). According to the matching hypothesis (Hunt, 1961), parents can contribute to their children's cognitive development by structuring interactions and support that align with their child's actual abilities. Parents with accurate judgments about their children's pre-existing

knowledge base are more likely to provide effective support, helping children connect their current understanding with new information (Hunt, 1961; Zippert & Ramani, 2016). In this regard, the more accurate parents are in judging their children's abilities, the more successful they are likely to be in scaffolding and supporting their children's learning effectively (Zippert & Ramani, 2016).

Literature on early childhood has documented that parents' ratings of their children's early numeracy strongly predict their children's early numeracy scores, even after controlling for direct assessments of other cognitive domains (Lin et al., 2021). With a high standardized regression weight of .71, the authors suggested that parent ratings could serve as an option to replace direct measures due to survey limitations (Lin et al., 2021), highlighting the strong relationship between parent judgment and children's early numeracy. However, literature has also shown that parents of preschool children tend to overestimate their children's cardinal understanding (Fluck et al., 2005) but underestimate their children's advanced number skills (Cannon & Ginsburg, 2008).

In comparison to information on parent judgment about language, there is less evidence available for parent judgment on early numeracy (Zippert & Ramani, 2016). One approach to gaining information about the relationship between parent judgment and the development of early numeracy is to investigate whether this relationship persists after children leave preschool. As reported by Aunola et al. (2003), parents' beliefs in their school-aged children's competence increased their children's task-focused behaviors at school, which further predicted the child's high level of math performance. More recently, although the impact of parent judgments does not appear to be robust over time, parent judgments alone can increase the incremental variance explained by 7% (Novita et al., 2023). In addition, a longitudinal study conducted by Bouffard & Hill (2005) documented that mothers' judgments of children's early numeracy in kindergarten were not significantly associated with later outcomes.

Current Study

This study aims to provide evidence regarding the early numeracy among Indonesian preschool children and to investigate whether the home numeracy activities, parent

expectations, and parent judgment can account for a significant portion of the variance in early numeracy among Indonesian children. Additionally, we propose that this effect will persist even after controlling for covariates such as age, gender, and socioeconomic status, as suggested by Anders et al. (2012). To address this objective, we propose that home numeracy activities, parent expectations, and parent judgment have significant relationships with early numeracy, as detailed below.

Hypothesis 1: Home numeracy activities make a significant contribution to explaining the variance in early numeracy among Indonesian preschool children, after controlling for age, gender, and socioeconomic status.

Hypothesis 2: There is a significant relationship between parent expectations and the early numeracy among Indonesian preschool children, after controlling for age, gender, and socioeconomic status.

Hypothesis 3: Parent judgment can explain a substantial portion of the variance in the early numeracy among Indonesian preschool children, after controlling for age, gender, and socioeconomic status.

Method

Sample

All participants in this study took part in both the first and second waves of the Numeracy and Language Study conducted in the Jatinangor district, Indonesia. Based on random sampling analysis using Unpad SAS (Jatnika et al., 2021), the number of samples should be a minimum of 30 preschools. A total of 30 randomized-selected preschools within Jatinangor district were invited to participate in the study and ten of them submitted positive responses. However, due to time constraints, one preschool could not participate in this study.

In the first wave, all four year old children and their parents within the nine participated preschools were invited to be part of the study. When parents submitted their consent, a child was invited to do the assessment (see the recruitment of the first wave study: Novita et al., 2024). After six months, a total of 84 preschool children (45% girls and 55% boys), with a

mean age of 59.56 months and a standard deviation of 5.29 were again assessed. The children underwent numeracy tests in both waves. Parents (94% of mothers) were asked to complete questionnaires about home numeracy activities, parent expectations in the first wave, and parent judgment in the second wave.

This study obtained ethical clearance with registered number 2206070666, and the ethical approval number is 906/UN6.KEP/EC/2022 from the ethics board of the commission. All parents have submitted their consent for the participation of their children and obtained money in amount of 30,000 Indonesian rupiah as reward for their participation. In addition, all participated children obtained a small gift (around 20,000 Indonesian rupiah) as a reward as well. The data collection was conducted between March-April 2023.

Instruments

Early Numeracy Test-Revised Version A and B

The Early Numeracy Test-Revised (ENT-R) is a task-oriented test designed to measure early numeracy. It comprises two parallel versions (Version A and B), each containing 45 items. Version A was used in Wave 1, while Version B was administered in Wave 2 to minimize carry-over effects. Both versions of ENT-R consist of nine components serving as indicators of early numeracy, including concepts of comparison, classification, correspondence, seriation, use of numerals, synchronized and shortened counting, resultative counting, general understanding of numbers, and estimations. Each component comprises five consecutive items. The total number of correct answers (0-45) was used in the analyses. Because both forms share an identical nine-component blueprint and 0–45 scoring, the construct is held constant across waves; the change modelled therefore reflects development across the 12-months interval rather than a difference in instrumentation. The reliability coefficient of the test was good ($R = 0.93$; van Luit & van de Rijt, 2009). In the current study, internal consistency was .90 for Version A and .88 for Version B.

Instruction examples covered concepts such as comparisons (e.g., Point out the lowest building), classification (e.g., Point out the picture with five blocks but no squares), correspondence (e.g., Point out the square where there is a straw for every glass), seriation (e.g., Point out the picture in which the candy canes are ordered from thin to thick), use of numerals (e.g., Count to twelve), synchronized and shortened counting (e.g., How many

fingers did you see in total?), resultative counting (e.g., How many pawns are on the table?), applying knowledge of numbers (e.g., He only waters twelve plants. How many plants did not get water?), and estimation (e.g., Put a tick on the line where the number 10 has to be).

Home Numeracy Activities

Home numeracy activities were measured using a questionnaire based on Kleemans et al. (2012), defining home numeracy activities as an indicator of the home numeracy environment, in addition to parent expectations. This scale was specifically chosen because the framework used in this instrument is aligned with those of this manuscript, although the breadth of the activity measured can be viewed as one of limitations of this instrument. The original Dutch questionnaire had a Cronbach's alpha of 0.79 for parent-child numeracy activities. The Cronbach's alpha coefficient for the Indonesian version was 0.82 (more specific item-level description can be viewed in the Appendix). The questionnaire comprised five items assessing parent-child numeracy activities, with responses rated on a five-point Likert Scale ranging from rarely (1) to several times a day (5).

Parent Expectation

As mentioned earlier, the questionnaire by Kleemans et al. (2012) includes both home numeracy activities and parent expectations. The parent expectation instrument showed good internal consistency of 0.92 for the Dutch version and 0.95 for the Indonesian version (see Appendix for item-level description). It included six items gathering information on how parents expect their children to master certain abilities. Parents were asked to what extent they expect their children for example to have mastered addition until 10 at the end of preschool, choosing from four options: not at all (1), a little (2), sufficient (3), and good (4).

Parent Judgments

The parent judgment questionnaire consists of two items. The first is an open-ended question for parents to evaluate their children's numeracy skills (e.g., "If your child is given 45 numeracy questions, such as choosing the most candies, how many questions do you think your child can answer correctly?"). The second item aims to compare the child's numeracy skills with other children of the same age. Parents were asked, "Compared to other children of the same age, your child's numeracy skills..." and asked to choose one option: much

worse (1), worse (2), the same (3), better (4), and much better (5).

Since a Cronbach's alpha is not regarded as an optimal approach for assessing the internal consistency of two-items scale, reliability was estimated using the inter-item correlation ($r = .27$) and the Spearman-Brown coefficient ($r_{SB} = .43$; Eisinga et al., 2013). Further, to combine the two items despite their distinct metrics, each item was standardized (z-scored) within the analytic sample, and the composite was computed as the mean of the two standardized items. In this respect, the two items capture complementary facets of parental judgment—an absolute performance estimate and a normative social comparison—rather than a single homogeneous construct. Further, unlike home activities and parent expectations, parent judgments were assessed in the second wave due to practical reasons in the field, which unfortunately related to high missing data (see Table 1). This point is regarded as one of the limitations of the study and is addressed carefully throughout the analysis.

Covariates

In this study, age (in months), the sex of the child (0 = girls, 1 = boys), and parents' income served as control variables. The age of the children and parents' education were obtained from the parents. Parents were asked to report their income based on a seven-point scale: less than 5 million rupiah “1,” between 5 and 10 million rupiahs “2,” between 11 and 20 million rupiahs “3,” between 21 and 30 million rupiahs “4,” between 31 and 40 million rupiahs “5,” between 41 and 50 million rupiahs “6,” more than 50 million rupiahs “7.” The sex of the child was collected by the test administrator during the numeracy performance test in kindergarten, with no reported issues in identifying the sex of the child.

Data Analysis

To examine the three hypotheses, a hierarchical block-entry regression was performed in RStudio version 2023.09.0-463 (Rstudio Team, 2020) using the SEM function from lavaan package version 0.6-16 (Rosseel, 2012). Missing data was treated using the FIML approach. In the first step, the early numeracy score was regressed against covariates: prior early numeracy, age and sex of children, and parent income. In the second step, home numeracy activities were included in the model. In the third step, parent expectation was additionally examined in the analysis. Finally, parent judgment was added in the fourth step.

Multicollinearity was assessed using variance inflation factors (VIFs). All predictors showed low VIFs, ranging from 1.08 (gender of child) to 1.63 (early numeracy wave 1), with a mean VIF of 1.30; corresponding tolerance values ranged from 0.61 to 0.93 (see Appendix, Table A3). These values are well below conventional thresholds for concern (VIF > 5–10; tolerance < 0.20), indicating that multicollinearity did not distort the estimation of the regression coefficients in the hierarchical block-entry model.

A sensitivity power analysis indicated that, with $N = 84$ and seven predictors, the study had 80% power ($\alpha = .05$) to detect effects of $f^2 \geq 0.10$ for a single predictor—that is, small-to-medium effects (Cohen, 1988). All statistical analyses and results can be viewed in this link that will be added after formal blinded peer review.

Results or Findings

Descriptive Results

The descriptive results are presented in Table 1. There is a relatively high percentage of missing data for parent judgment, which will be explained more later. The ratio of girls to boys is relatively comparable. Furthermore, while two parents reported a very high income

Table 1. *Descriptive statistics for covariates*

	% Missings	Min.	Max.	Mean	<i>SD</i>	%
Early numeracy wave 1	0	1	40	17.61	8.75	
Early numeracy wave 2	0	6	43	19.89	8.48	
Home numeracy activities	0	0	25	14.52	5.01	
Parent expectation	0	0	24	20.01	5.34	
Parent judgment	55	7	50	35.95	11.38	
Age of child*	0	48	67	59.56	5.29	
Gender of child	0					
Girls						45
Boys						55
Parent income	4	1	7	1.77	1.30	

Note. $N = 84$. * = age in wave 1.

of more than 50 million rupiahs (coded as 7), more than half (58%) of parents have an income of less than 5 million rupiahs per month, and the mean income is relatively low. This output suggests that the sample of this study may be more pronounce for population with low socioeconomic status in Indonesia.

Result for Hypothesis Testing

The results of Pearson bivariate correlation analysis for all relevant variables are presented in Table 2. According to Table 2, there were significant correlations found: between parent judgment and early numeracy in both first and second waves, between parent judgment and home numeracy activities, between home numeracy activities and parent expectation. In addition, since age was specifically controlled in wave 1 (see sample section), no significant relationship c'found for this construct while some significant findings are found for both gender and parent income (see Table 2).

Table 2. *Correlations*

	1	2	3	4	5	6	7
1. Early numeracy T2 (DV)							
2. Early numeracy T1 (covariate)	0.48**						
3. Home numeracy activities	0.02	-0.11					
4. Parent expectation	0.15	0.08	0.40**				
5. Parent judgment	0.53**	0.46**	0.29*	0.16			
6. Age of child	0.14	0.19	-0.13	0.05	-0.08		
7. Gender of child	-0.02	-0.33**	-0.21*	-0.07	-0.42**	-0.06	
8. Parent income	0.04	0.30**	0.14	-0.06	0.22	-0.35**	-0.20

Note. N = 84. Correlation analysis was performed after full-information maximum likelihood (FIML) estimation. * = $p < .05$. ** = $p < .01$

Results of hierarchical block-entry regression are presented in Table 3. According to Table 3, analysis of parent judgment (Model 4) yielded a significant relationship with early numeracy, even after controlling for prior early numeracy scores. Therefore, we can confirm hypothesis 3 about the meaningful relationship between parent judgment and early numeracy.

However, we cannot confirm hypotheses 1 and 2 because the analysis found no significant links between both parent home numeracy activities as well as parent expectation and early numeracy (see Model 2 and 3).

Table 3. *Results of Stepwise Regression Analysis*

	Model 1: Covariate	Model 2: home numeracy activities	Model 3: Parent expectation	Model 4: Parent judgment
Prior early numeracy	0.53** (0.11)	0.56** (0.11)	0.55** (0.11)	0.33* (0.13)
Age (in years)	0.03 (0.17)	0.04 (0.17)	0.04 (0.17)	0.22 (0.17)
Gender (ref: girls)	2.36 (1.70)	2.99 (1.74)	2.92 (1.74)	3.69* (1.75)
Parent income	-0.58 (0.73)	-0.71 (0.73)	-0.66 (0.73)	-0.41 (0.83)
Home numeracy activities		0.24 (0.17)	0.20 (0.19)	0.12 (0.19)
Parent expectation			0.09 (0.17)	0.13 (0.18)
Parent judgment				0.31** (0.10)
R ²	0.258	0.276	0.279	0.411

Note. N = 84. Regression coefficient (SE). * = $p < .05$. ** = $p < .01$.

Table 3 presents the hierarchical regression predicting wave 2 early numeracy under FIML estimation (N = 84). The covariate block (prior early numeracy, age, gender, parent income) explained 25.8% of the variance, driven by prior early numeracy ($b = 0.53$, $SE = 0.11$, $p < .001$). Adding home numeracy activities (Model 2) and parent expectation (Model 3) yielded negligible increments ($\Delta R^2 = .018$ and $.003$; both ns), and neither predictor was significant. Adding parent judgment (Model 4) produced the only substantial increment ($\Delta R^2 = .133$), raising total explained variance to 41.1%. Parent judgment was a significant concurrent correlate ($b = 0.31$, $SE = 0.10$, $p = .002$), indicating it accounted for variance beyond prior numeracy and the other parental factors. Because parent judgment was measured concurrently with the Wave 2 outcome, this association is interpreted as concurrent rather than predictive. Prior early numeracy remained a positive, significant predictor in the full model ($b = 0.33$, $SE = 0.13$, $p = .013$), and gender reached significance ($b = 3.69$, $SE = 1.75$, $p = .035$), with boys scoring higher. This finding may reflect a common gender stereotype that boys are better at numeracy/mathematics subject.

Due to high missing data of parent judgment (see Table 1), we performed two sensitivity analyses to test whether the found effect depended on the missing-data treatment. In a complete-case analysis with no imputation, parent judgment remained significant ($b = 0.26$, $SE = 0.11$, $p = .027$). Under multiple imputation ($m = 30$, predictive mean matching, with the outcome included in the imputation model as recommended by Moons et al., 2006), the pooled estimate was virtually identical ($b = 0.24$, $SE = 0.11$, $p = .029$). Across FIML, complete-case, and multiple imputation, the estimate remained stable ($0.24 - 0.31$) and significant, indicating the association is not an artifact of the missing-data method.

Discussion and Limitation

This study aims to disentangle the relationships between home numeracy environment, parent judgments, and early numeracy skills in Indonesia. These findings should be explained within the specific characteristics of the sample, which included children from nine preschools in Jatinangor district, their parents, and predominantly from low-income families. Within this context, parent judgement emerged as the only parental factor significantly associated with children's early numeracy, whereas home numeracy activities and parent expectation did not show significant associations.

Insignificant Findings of Home Numeracy Activities and Parental Expectations

Home numeracy environment is part of the home learning environment that includes parents' beliefs and attitudes about children's numeracy learning, as well as their participation in supporting their children's numeracy development at home (Dearing & Tang, 2010; Manolitsis et al., 2013). Within this definition, any perceptions parents have about their children's numeracy learning and the activities parents engage in with their children to support early numeracy are considered part of the home numeracy environment. Our study has revealed that two types of parental factors, namely home numeracy activities and parental expectations, do not exhibit a statistically significant association with the early numeracy levels of Indonesian preschool children, the majority of whom originate from low-income

households. This finding should not be interpreted as evidence that home numeracy is unimportant. A study conducted with Mexican children reported that a significant relationship between home numeracy environment and early numeracy achievement only exists for children from high socioeconomic status (Susperreguy et al., 2021). According to Susperreguy et al. (2021), this phenomenon is due to at least three aspects. First, parents from different socioeconomic backgrounds may provide distinct types of educational materials and learning experiences for their children (Starkey & Klein, 2007). Second, parents from different socioeconomic backgrounds may have various knowledge about children's skills and how to foster them (Zippert & Ramani, 2016). Third, parents with low socioeconomic status may engage in learning activities that support early numeracy, but they may not be aware of it and may not report these activities in the questionnaire (Starkey & Klein, 2007).

In Western culture, informal activities such as playing board games, carpentry or measuring objects are commonly understood as opportunities to support children's mathematical competence (Skwarchuk et al, 2014). However, our findings suggest that Western-based models of informal learning may not directly align with the structural and socio-cultural of low-income Indonesian households. In this context, numeracy learning may be embedded in daily activities, such as counting objects during household tasks, counting change at a local shop, or sharing food among family members. Yet, these practices may occur naturally as part of daily life, parents may not always recognize or report them as intentional numeracy learning.

These findings also align with Indonesia's early educational context. For many years, school readiness has often been socially associated with "calistung" competence, an acronym for *baca*, *tulis*, and *hitung* referring to reading, writing, and arithmetic. Although national regulation has stated that the admission process for the first-grade school should not be based on reading, writing, and/or arithmetic tests (Ministry of education and Culture, 2021), the social meaning of school readiness may not be immediately reflected in everyday parental practices. Some parents may still define real mathematics competence as formal and symbolic tasks, such as recognizing numbers, counting aloud, writing numbers, or completing arithmetic exercises. This may partly explain why informal activities e.g., counting object during household task are less likely to be identified as numeracy learning—a gap that deserve more exploration in future research.

Significant Findings of Parent Judgment

According to the matching hypothesis (Hunt, 1961), cognitive scaffolding requires a parent to structure interactions and provide support that align with their children's actual abilities. The more accurate parents are in judging their children's abilities, the more successful they are likely to be in scaffolding and supporting their children's learning effectively (Zippert & Ramani, 2016). While parents in low-income Indonesian households may include their children in daily activities that possess numeracy properties, these activities may be less likely to be accompanied by explicit numeracy learning. Parents may not identify them as learning opportunities as they may also have limited awareness or access to information about early childhood numeracy milestones, which may affect how they interpret, support, and report their children's numeracy experiences.

An alternative explanation for the lack of significant findings concerning the home numeracy environment stems from the socio-cultural perception of education in Indonesia that emphasizes the school and formal academic setting as authorities on learning. Common practice among Indonesian parents of enrolling their preschool children in private courses focusing on literacy and numeracy. Parents may view their role not as teachers or pedagogical facilitators, but as financial providers who facilitate access to these external sources. This unique phenomenon lends weight to the argument regarding the insignificance of findings related to the home numeracy environment, as there appears to be a tendency among Indonesian parents to delegate their role as primary influencers in this environment to external providers. However, the absence of data regarding children's participation in private courses necessitates further investigation to confirm this assumption.

In contrast to the outcomes observed for both home numeracy activities and parental expectations, a noteworthy finding emerged regarding parental judgment. Previous research has consistently shown significant correlations between parental judgment and their children's cognitive abilities (Novita et al., 2023; Segers et al., 2015; Zippert and Rittle-Johnson, 2018). One plausible explanation for these results can be derived from the concept of the self-fulfilling prophecy, which posits that children tend to perform at the level their parents believe them to be capable of achieving. Parents' perception of children's competence may influence the learning opportunities and the level of challenge they provide

at home. When parents perceive their children capable, they may be provided numeracy-related activities that encourage the children to engage and explore mathematical ideas. In line with this, previous study has also found that, parents who perceive their children as highly competent cognitively are more likely to foster competence in them compared to those who do not (e.g., Bouffard & Hill, 2005). This outcome can be further elucidated by examining the link between judgment and behavior (Miller, 1988). Variations in parental judgment influence their interactions with their children (Novita et al., 2023; Segers et al., 2015; Zippert and Rittle-Johnson, 2018), potentially dictating the level of investment they make in their child's education, including hiring tutors (Kinsler & Pavan, 2020), as previously mentioned.

In this study, the correlation between early numeracy in the first (T1) and second waves (T2) yielded 0.48 ($p < .01$), while the correlation between parental judgment and early numeracy in the second wave is 0.53 ($p < .01$), suggesting that parent judgment has an incredible relationship with early numeracy that even slightly higher than the correlation with the same construct measured six months before. Furthermore, the effect of early numeracy in the first wave diminishes when parental judgment is included in the model (see Table 3, model 4), indicating that parental judgment was associated with early numeracy even after accounting for potential effects of prior competence. This finding underscores the substantial relevance of parental judgment in explaining the variance of early numeracy as an outcome variable in this study. The outcome of this study, revealing a robust relationship between parental judgment and early numeracy, suggests that parental judgment in the preschool setting may provide complementary information about children's numeracy competence. Parents interact with children across everyday home contexts that may not always be visible in school settings. Therefore, parent judgement may capture the children's numeracy competence that are embedded in daily routine. However, further comprehensive research is warranted to validate this preliminary assertion.

Additional Results

Moreover, the results of this study also support some findings reported in the literature of early childhood. For example, a significant correlation between parent expectation and home

numeracy activities indicated that the higher parents expect that their children are capable of doing some numeracy tasks, the more likely they are to engage in home numeracy activities, which is consistent with other studies conducted in other countries (del Río et al., 2017).

Interestingly, there are no significant relationships found between both home numeracy activities as well as parent expectation and parent judgment. It is possible that this result was a consequence of different measurement points between both home numeracy activities and parent expectation (measured in the first wave) and parent judgment (measured in the second wave). Another possible explanation for these results is, again, due to the low-income status of the majority of our participants. With this specific characteristic, parents might encounter difficulties in accurately comparing their children's numeracy skills with other children due to a lack of knowledge about their children's development—parents are unaware of their child's current numeracy skills as a baseline and next milestone. It is also possible that parents may not have access to sufficient information on their child's performance, for example, normative feedback from teachers (Lohbeck & Moller, 2017). This condition might lead parents to judge their child's ability inaccurately as they do not understand how to improve it through scaffolding. Although parents engage their children in number-related activities, parents' judgments suggest they have misconceptions about the development of numeracy skills. This could have an impact on the quality of related experiences parents provide their children. Our view is supported by Zippert and Ramani (2016) who argue that parents engage in number-related activities at home regardless of their judgment about children's numeracy abilities.

Limitations

Although this study provided several important findings, it has some limitations. First, the sample size was relatively small and drawn from 9 preschools in one district, which limits the generalizability of the findings to Indonesian preschool children more broadly. In addition, given $f^2 \geq 0.10$, effects smaller than this may have gone undetected, which is also more pronounced for parent judgment, with 55% missing data. Results should therefore be interpreted with appropriate caution regarding small effects. Second, although most children come from low-income families, not all children have these characteristics. Therefore,

although we may assume that the results may be related to the low-income status, a more precise statement can be made only if the participants' characteristics are limited to children from low-income families. Third, most parent respondents were mothers which limits our understanding of paternal influence and broader parental influences. Fourth, the parental variables relied on self-report, which may be influenced by recall bias, social desirability, and cultural response tendencies. Fifth, the home numeracy activities and parental expectations were assessed at wave 1 and thus prospectively preceded the wave 2 numeracy outcome, whereas parent judgment was assessed concurrently at wave 2. Although this placement reflects the appraisal-based nature of parent judgment, it precludes causal-directional claims for this variable: parents' judgments may reflect, rather than shape, children's demonstrated numeracy as also recognize in this manuscript. Finally, this study did not control for other cognitive skills that are relevant for early numeracy such as intelligence (Niklas & Schneider, 2013).

Conclusion

This study aims to examine the relationship between various parental factors (i.e., home numeracy environment, parent expectation, and parent judgment) and early numeracy in Indonesian preschool children, controlling for prior early numeracy. The participants of this study predominantly come from low-income families. Parent judgment showed a relatively similar correlation with prior early numeracy and the effect of prior early numeracy disappears when parent judgment was included in the model, suggesting that parents' perceptions may offer complementary information for understanding children's numeracy competence in everyday activities in home context. This result sheds light on one crucial factor that may explain children's cognitive outcomes related to later academic achievement, such as school readiness and PISA performance: parental judgment. However, this findings should be interpreted cautiously due to the small sample, the predominance of low-income families, the high proportion of missing data, and the reliance on parent self-report measures that may be influenced by cultural beliefs and response tendencies. Future studies should involve larger and more diverse samples, culturally sensitive measures, and multiple sources

of assessment such as parent reports, teacher judgement, and direct child assessment.

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Appendix

Measurement Characteristics of the Parental Variables

All statistics were computed on the final analytic sample ($N = 84$), that is, participants with valid Wave 2 early-numeracy data who met the a priori inclusion criteria. Home numeracy activities and parental expectations were adapted from Kleemans et al. (2012).

Table A1. *Item-Level Descriptive Statistics and Corrected Item–Total Correlations for the Parental Measures ($N = 84$)*

<i>Measure / item</i>	<i>M</i>	<i>SD</i>	<i>Range</i>	<i>% missing</i>	<i>r(item–total)</i>
<i>Home numeracy activities ($\alpha = .82$)</i>					
Counting together (A_hitung)	3.83	1.09	1–5	1.2	.46
Ordering numbers (A_urut)	3.12	1.24	1–5	1.2	.71
Number games/play (A_main)	2.51	1.26	1–5	1.2	.60
Working with numerals (A_numerik)	2.95	1.26	1–5	1.2	.68
Counting rhymes (A_hitungrima)	2.29	1.41	1–5	1.2	.59
<i>Parental expectations ($\alpha = .95$)</i>					
Count objects in groups (H_hitungkelompok)	3.65	0.65	1–4	1.2	.72
Count to 20 (H_hitung20)	3.49	0.79	1–4	1.2	.79
Addition up to 10 (H_jumlah10)	3.42	0.90	1–4	1.2	.87
Addition up to 20 (H_jumlah20)	3.28	0.99	1–4	1.2	.91
Subtraction up to 10 (H_kurang10)	3.28	1.01	1–4	2.4	.93
Subtraction up to 20 (H_kurang20)	3.17	1.06	1–4	1.2	.91
<i>Parental judgment (2 items; standardized composite)</i>					
Estimated no. correct out of 45 (E_Num1_OII)	32.34	11.15	3–45	54.8	—
Social-comparison rating, 1–5 (E_Num2_OII)	3.63	0.73	2–5	51.2	—

Note. Item labels in parentheses are the variable names; the preceding descriptions are abbreviated summaries and should be aligned with the exact questionnaire wording. Home numeracy activities were rated on a 5-point scale (1 = *rarely* to 5 = *several times a day*); parental expectations on a 4-point scale (1 = *not at all* to 4 = *good*). The two parental-judgment items are recorded on different metrics and were therefore z-standardized before being averaged into a composite; corrected item–total correlations are not reported for a two-item measure.

Table A2. *Internal Consistency of the Parental Measures (N = 84)*

<i>Measure</i>	<i>No. of items</i>	<i>Reliability estimate</i>	<i>95% CI</i>	<i>n</i>
Home numeracy activities	5	$\alpha = .82$	[.75, .87]	83
Parental expectations	6	$\alpha = .95$	[.93, .97]	82
Parental judgment	2	$r = .27$; $r_{SB} = .43$	—	38

Note. α = Cronbach's alpha; 95% CIs were computed using the Feldt method. For the two-item parental-judgment measure, Cronbach's alpha is inappropriate; reliability is therefore indexed by the inter-item correlation ($r = .27$; Spearman $\rho = .25$) and the Spearman-Brown coefficient ($r_{SB} = .43$). The two items capture complementary facets of parental judgment.

Table A3. *Collinearity Diagnostics for the Hierarchical Block-Entry Regression Model (N = 84)*

<i>Predictor</i>	<i>VIF</i>
Baseline early numeracy (EN_W1)	1.63
Age	1.28
Sex	1.08
Household income	1.16
Home numeracy activities	1.40
Parental expectations	1.24
Parental judgment	1.32
Mean	1.30

Note. VIF = variance inflation factor; tolerance = $1/VIF$. Predictors were entered in predefined conceptual blocks (hierarchical block-entry), not through a data-driven stepwise procedure. All VIFs were well below conventional thresholds for concern ($VIF > 5$ – 10), indicating that multicollinearity did not distort the coefficient estimates.