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Family and individual variables associated with young Filipino children's numeracy interest and competence

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Children's early numeracy outcomes set the foundation for mathematics learning in their future school years. This study examined how different family and individual variables were associated with the numeracy interest and competence of disadvantaged young children in the Philippines. The numeracy and literacy skills of 673 children living in low-middle income communities were tested. Their parents were also asked to complete a questionnaire on demographics, their home numeracy practices, attitudes about numeracy learning, and children's numeracy interest. Structural equation modelling analyses showed that children's numeracy interest was linked with their parents' practices and attitudes. Children's numeracy competence, on the other hand, was related to their gender, age, socioeconomic status, and literacy abilities. These findings suggest that family and individual variables might play different roles in disadvantaged children's early numeracy development. Moreover, parents can be encouraged to make effective use of home numeracy experiences to promote their children's numeracy competence.

Statement of contribution

What is already known on this subject?

- In developed countries, home environment is occasionally found to link with early numeracy development.
- Some individual variables are also found to play significant roles in early numeracy development.

What does this study add?

- Among young Filipino children from disadvantaged backgrounds, home environment is related to numeracy interest.
- Family socioeconomic status plays a significant role in early numeracy competence.
- Early literacy and numeracy skills are interrelated with each other.

It is important to foster children's numeracy interest and competence in the early years of life. On the one hand, positive attitudes towards mathematics can motivate children to learn advanced knowledge (Fisher, Dobbs-Oates, Doctoroff, & Arnold, 2012). On the other hand, early proficiency in mathematics can boost children's confidence to learn new

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knowledge and facilitate their mastery of sophisticated concepts (Fisher *et al.*, 2012; Jordan, Kaplan, Ramineni, & Locuniak, 2009).

Some family (e.g., home numeracy environment) and individual variables (e.g., literacy abilities) have been identified as correlates of early numeracy development in developed countries. Nevertheless, it is unclear whether the same holds true in developing countries. This can have important practical implications in terms of how interventions should be structured in such contexts. This study, thus, sought to identify family and individual correlates of the numeracy interest and competence of disadvantaged young children in the Philippines, where socioeconomic disparities are relatively pronounced and institutionalized.

Home environment and early numeracy development

Home numeracy environment involves both parents' practices (e.g., the amount and types of learning resources they provide children with and the frequency and nature of learning activities they engage children in) as well as attitudes (e.g., their perceptions of the importance of early numeracy learning; Anders *et al.*, 2012; Blevins-Knabe, 2016; Segers, Kleemans, & Verhoeven, 2015). In the recent two decades, there has been growing interest in the role of home environment in early numeracy development among researchers. Perhaps disappointingly, results of studies on children in developed countries have been equivocal. Anders *et al.* (2012) showed that numeracy-related activities and resources at home predicted young German children's numeracy competence. LeFevre, Polyzoi, Skwarchuk, Fast, and Sowinski (2010) found that the more Canadian kindergartners engaged in home activities that directly addressed numbers and simple arithmetic, the better their knowledge of numeration and number sequence. Kleemans, Peeters, Segers, and Verhoeven (2012) demonstrated that Dutch parents' expectations about children's numeracy abilities were positively associated with their kindergarteners' performances on numeracy tasks. Lee and Kim (2016) showed that the more Korean mothers favoured the constructivist approach to mathematics learning (i.e., constructing mathematics knowledge through hands-on experiences with objects and social interactions), the better their young children's mathematical abilities. Nevertheless, Blevins-Knabe, Austin, Musun, Eddy, and Jones (2000) found no relation between the frequency of home numeracy activities and mathematical test scores among young American children. Missall, Hojnoski, Caskie, and Repasky (2015) also showed that American preschoolers' mathematics performance was not linked with their engagement in mathematical activities at home or with their parents' positive beliefs about mathematics.

Relatively few studies have focused on the relations between home environment and young children's beliefs and attitudes towards mathematics. Again, their results varied. Cheung and McBride (2017) showed that parent–child number board game playing could help promote Hong Kong kindergarteners' mathematics interest. In a study by Lee and Kim (2016), young Korean children's attitudes towards mathematics were positively associated with their mothers' level of support for the constructivist approach to mathematics learning. Children's participation in learning activities at home, however, was not a significant correlate (Lee & Kim, 2016).

These findings regarding the relation between home environment and numeracy development were inconsistent across studies perhaps because: (1) These studies adopted different research instruments to assess home numeracy environment, children's numeracy interest, and competence; and (2) they took different other individual and contextual variables into account. For example, in terms of the operationalization of home numeracy environment, some researchers (e.g., Manolitsis, Georgiou, & Tziraki, 2013) examined only parent–child activities but not parental attitudes. In addition, although some parents reported in questionnaire studies (e.g., Skwarchuk, Sowinski, & LeFevre, 2014) that they engaged their young children in a variety of numeracy activities at home, observational studies (e.g., Vandermaas-Peeler, Ferretti, & Loving, 2012) have revealed that some parents were not aware of the effective strategies of fostering children's numeracy competence during these activities. Furthermore, in some studies (e.g., Missall *et al.*, 2015), the effects of young children's demographic background and literacy abilities had not been fully taken into consideration when untangling the relation between family variables and children's numeracy development. In this study, in order to obtain a clearer picture of young Filipino children's numeracy development in relation to home numeracy environment, we examined both parents' practices and attitudes and also considered the contributions of various individual variables to numeracy development.

Children's demographics, early literacy, and numeracy development

Some basic demographics variables, including gender, age, family socioeconomic status (SES), and preschool attendance, have been associated with numeracy development of young children in developed countries. The differences, when found, generally favoured boys, older children, children from more affluent families, and children who had attended higher-quality preschools. For example, Else-Quest, Hyde, and Linn (2010) found, in a meta-analysis, that boys generally held more positive attitudes towards mathematics than girls. In a study of American kindergarteners by Jordan, Kaplan, Nabors Oláh, and Locuniak (2006), boys performed slightly better than girls on non-verbal calculation skills, and older children showed better overall number sense than younger ones. Compared to children from middle-income families, children from low-income families performed less well on many number sense tasks (Jordan *et al.*, 2006). Starkey, Klein, and Wakeley (2004) also found that American pre-kindergarteners from low-income families lagged behind their peers from middle-income families in informal numerical knowledge. Similarly, Melhuish *et al.* (2008) showed that family SES was a predictor of British children's numeracy skills at age five, and the effectiveness of the preschool centre British children attended at age five was associated with their numeracy outcomes at age seven. In addition, Anders *et al.* (2012) found that some structural characteristics of the preschool centre that German children attended (e.g., the child–staff ratio) were correlated with their numeracy skills.

To a certain extent, the above differences can be explained by differential socialization practices. Boys are often raised to feel more confident and interested in doing mathematics (Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005). Older children generally have had more experience in practicing numeracy skills (Aunio & Niemivirta, 2010). Parents who come from a lower SES background and preschools of lower quality have also been found to provide somewhat less support for children to learn early numeracy concepts (Sammons *et al.*, 2005; Starkey & Klein, 2008). It was, therefore, of particular interest to examine in this study whether these individual demographics variables are unique correlates of numeracy development when their contributions are studied together with those of the home numeracy environment, especially in contexts where impoverished families are relatively common.

Different early literacy skills have also been found to be interwoven with various aspects of mathematics knowledge among young Western children. For example, LeFevre *et al.* (2010) found that young Canadian children's elision and vocabulary skills predicted their number naming skills. Purpura, Hume, Sims, and Lonigan (2011) showed that American preschoolers' print knowledge and vocabulary correlated with their knowledge in counting, numerical relations, and arithmetic operations. Jordan *et al.* (2006) demonstrated that American kindergarteners' reading proficiency predicted their performance on numeral recognition, counting, and calculation. Kleemans *et al.* (2012) found that Dutch kindergarteners' performance on rhyming, blending, and receptive letter knowledge tasks was positive correlates of their numeracy skills, including counting and quantitative comparison. Purpura and Napoli (2015) looked more closely into the underlying mechanisms by which mathematics and literacy performances overlap, using a sample of American preschoolers. They found that early literacy skills influenced the acquisition of numeral knowledge through their effect on informal numeracy skills (e.g., verbal counting). These studies suggest that the role of literacy abilities cannot be overlooked when examining the relations between home numeracy environment and early numeracy development.

The context of the Philippines

The Philippines is a lower middle-income developing country characterized by high inequality between the rich and the poor and an estimated poverty rate of 26% (Philippine Statistics Authority, 2016a; World Bank, 2016). Despite strong beliefs on the importance of education among Filipinos, the Philippines lags behind in international assessments of mathematics and science (Bernardo, 2003).

Many published findings about early numeracy development, including studies cited in this article, have originated from developed countries. Research evidence from less represented areas of the globe may be valuable in establishing generalizability of previously reported results and in assessing areas that require further intervention. As mentioned by Nag, Chiat, Torgerson, and Snowling (2014), children in developing countries face unique challenges in acquiring good literacy and numeracy education. For example, numeracy instruction in these contexts has been characterized by rote-type instruction and the use of abstract language. Bautista and Mulligan (2010) found that Filipino children from disadvantaged backgrounds struggled to solve word problems in English (the primary language of instruction for mathematics at the time) due to their low oral proficiency in the second language, and relied on familiar, but sometimes inappropriate, arithmetic operations as a result (Bautista, Mitchelmore, & Mulligan, 2009).

Nevertheless, Huang (2009) found that family SES, rather than school quality indicators, was still more prominent as a factor for Filipino children's mathematics ability at 11 years old. Parental education, household expenditure, and length of school attendance significantly accounted for children's mathematics performance. Furthermore, an intervention wherein school feeding was combined with increased parent–teacher partnerships had a positive impact on Filipino children's mathematics scores (Tan, Lane, & Lassibille, 1999). Thus, the family represents a crucial context in which to examine Filipino children's early experiences with numeracy.

Present study and proposed model

This study aimed to assess the relative associations of different family and individual variables to the numeracy interest and competence of disadvantaged young children in the Philippines. The variables included in our model testing were children's gender, age, and preschool experience, family SES, children's literacy abilities, and parents' reported practices, and attitudes about numeracy learning. These were selected because they have often been found to link with children's early numeracy development in developed countries (Anders *et al.*, 2012; Jordan *et al.*, 2006; Lee & Kim, 2016).

Based on past research findings, we proposed a model explaining young children's numeracy interest and competence (Figure 1). In view of the fact that one's attitude to mathematics is closely related to one's experiences with mathematics (Ruffell, Mason, & Allen, 1998) and that the gender gap in attitudes towards mathematics is not apparent in the early years of life (Fisher *et al.*, 2012), we hypothesized that only the two family variables (parents' practices and attitudes) would be significant correlates of children's numeracy interest. We also speculated that all seven variables included would show significant relations with children's early numeracy competence. In addition, we expected that there would be a significant linkage between children's numeracy interest and competence: Children with better numeracy competence might enjoy doing mathematics more, and those with more interest in mathematics might have a stronger motivation to acquire and practice numeracy skills (Middleton & Spanias, 1999).

Method

Participants

Participants were 673 Filipino children (53% male) living in four neighbouring low- to middle-income communities within Cebu City, the Philippines. These urban communities had a combined population of 36,329 (Philippine Statistics Authority, 2016b). Many areas were dense, and most houses were made of a mixture of concrete and scrap materials. Many residents worked as fish or food vendors, laundry washers, and labourers.

Recruitment was carried out by a partner non-government organization that formalized agreements with local government units. Teachers enlisted 817 families who expressed initial interest to participate in a parent coaching programme. At the time of assessment, 106 families were not located, 17 families did not give parental consent, 16 families had children who did not meet the age criteria of this study, and five families had children who could not be assessed. Difficulty in locating families was due to high residential mobility and the lack of formal addresses for accurate reference.

Children's ages ranged from 33 to 71 months (M = 51.11 months, SD = 10.09). Among parent respondents, 80% were mothers, 8% were fathers, and the rest were extended family members such as grandparents and aunts or uncles. All participants spoke Cebuano as their mother tongue, but were also likely to speak some Filipino and/or English.

Measures

A parent questionnaire was used to collect information about children's demographics, parents' practices and attitudes, and children's numeracy interest.

Children's demographics

The parent questionnaire asked about children's gender, age, attendance to preschool or not, and SES (including parents' educational level and average family income). Mother's and father's highest levels of education were indicated, respectively, on a scale of 1–8

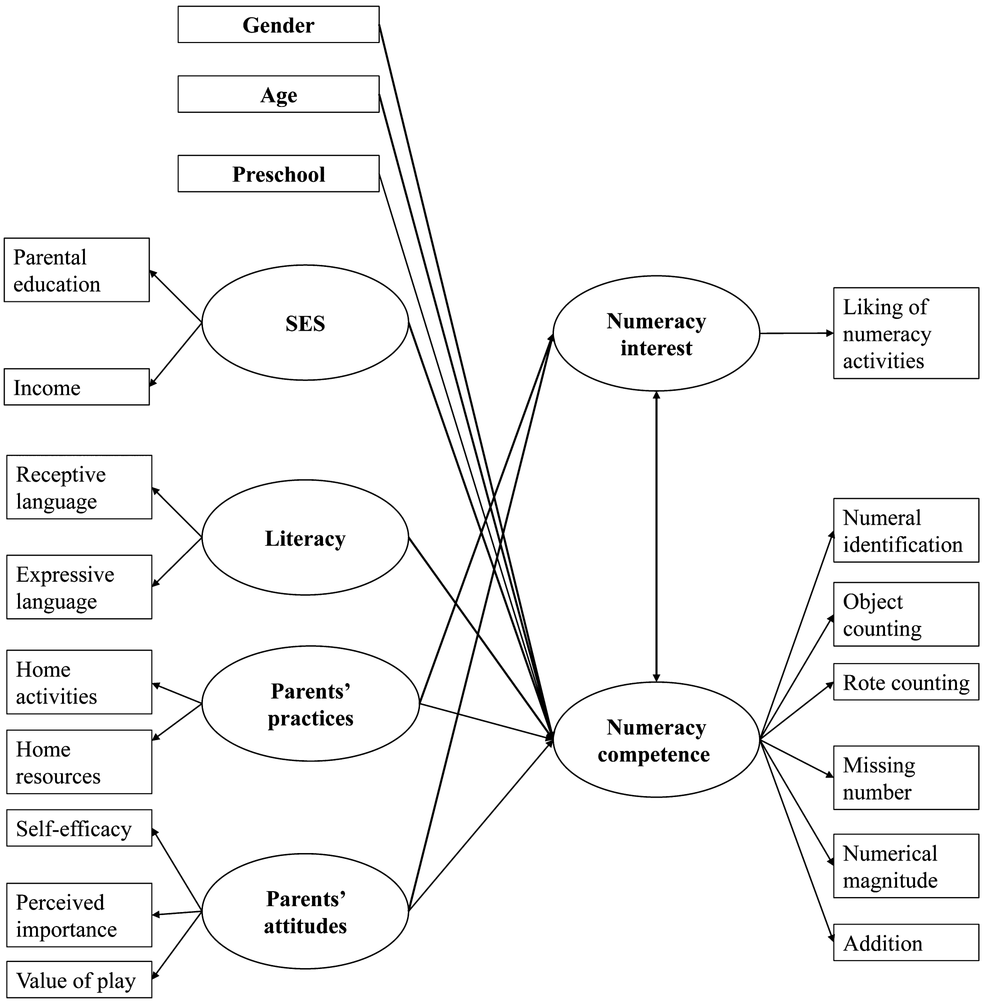

Figure 1. Proposed model for numeracy interest and numeracy competence explained by gender, age, attendance to preschool, socioeconomic status (SES), literacy abilities, parents' practices, and parents' attitudes. Ellipses reflect latent variables, and rectangles indicate observed variables.

(Appendix A). Average family income was reported as daily income or as monthly income divided by 21.75 days.

Parents' practices

Based on related past studies (LeFevre *et al.*, 2009; Missall *et al.*, 2015; Ramani & Siegler, 2011; Skwarchuk, 2009), a list of seven types of home numeracy activities and four types of home numeracy resources were identified. Parents were asked to indicate on a scale of 1–6 how often they engaged their children in each type of numeracy activities (e.g., reading children's books related to numbers) at home and a scale of 1–5 the extent to which each type of numeracy resources (e.g., children's books related to numbers) was available at home (Appendix A). Results of principal component analysis showed that for both measures, only one factor with eigenvalues larger than one could be extracted (home numeracy activities: eigenvalue = 4.50, 64.27% of variance explained, factor loadings ranged from 0.72 to 0.86, α = .91; home numeracy resources: eigenvalue = 2.57, 64.12% of variance explained, factor loadings ranged from 0.75 to 0.85, α = .81).

Parents' attitudes

Three types of parental attitudes were assessed. Parents were asked to indicate on a scale of 1–6 whether each of the statements provided was a correct description of their view or situation (Appendix A). For parents' self-efficacy in teaching young children numeracy, three items (e.g., 'I am good at helping my child work through problems about numeracy learning'.) were used. They were modified from the *Facilitating Child's Achievement in School* subscale of the *Self-efficacy for Parenting Tasks Index* developed by Coleman and Karraker (2000). For parents' perceived importance of their roles in early numeracy learning, four items were developed based on the scale by Cheung, McBride, and Dulay (2015). A sample item was 'Parents play an important role in preschool children's numeracy development'. For parents' perceived value of play in early numeracy learning, four items (e.g., 'Play is an important platform for preschool children to learn about numbers'.) were constructed based on the ideas of parents in the study of Cannon and Ginsburg (2008). Results of principal component analysis showed that for all three measures, only one factor with eigenvalues larger than one emerged (self-efficacy: eigenvalue = 1.77, 59.03% of variance explained, factor loadings ranged from 0.74 to 0.81, α = .64; perceived importance: eigenvalue = 2.24, 56.00% of variance explained, factor loadings ranged from 0.66 to 0.81, α = .73; value of play: eigenvalue = 2.33, 58.14% of variance explained, factor loadings ranged from 0.72 to 0.78, α = .76).

Children's numeracy interest

Based on past studies that had assessed children's numeracy interest (e.g., Cheung *et al.*, 2015), a list of six numeracy activities (e.g., participating in numeracy games) was created. Parents were asked to rate on a scale of 1–6 the extent to which their children liked each of the activities (Appendix A). Principal component analysis suggested that the scale consisted of only one factor (eigenvalue = 3.51, 58.45% of variance explained, factor loadings ranged from 0.69 to 0.82, α = .86).

In addition, children were individually tested on their literacy and numeracy competence.

Children's literacy abilities

Both receptive and expressive language skills were assessed. For receptive language (Spearman–Brown r = .80), the design of the 20-item test was adapted from the *PPVT-III* (*Peabody Picture Vocabulary Test III*, Dunn & Dunn, 1997). Words and pictures were selected in relation to age and cultural appropriateness. Children were shown four pictures and were asked to point to the picture that matched the Cebuano word spoken by the experimenter. The ceiling level was set at five consecutive errors. For expressive language (r = .64), children were shown 10 pictures and were asked to label them orally. Although children were instructed to respond in Cebuano, it was typical for individuals from multilingual urban Filipino samples to sometimes respond in Filipino or English.

Thus, one point was given for direct Filipino or English translations of the target Cebuano word.

Children's numeracy competence

Six number sense tasks that were used by Cheung and McBride-Chang (2015) were adopted, but some of the items were modified to make their difficulty level suitable for our participants. The ordering of the items in each measure generally followed a trend of progressive difficulty. Appendix B showed details about the difficulty level of items and ceiling level in each measure.

The *Numeral Identification* task (Spearman–Brown $r = .97$) consisted of 20 items. Children were required to name the numerals provided on a sheet one by one. The *Object Counting* task ($r = .97$) had 14 items. In each item, children had to tell the number of animals shown on a sheet by counting them aloud one by one. The *Rote Counting* task ($r = .82$) included four items. Children were instructed to begin counting orally from a given number to another given number (e.g., from 1 to 10). The *Missing Number* ($r = .96$) task had 12 items. Each time, children had to identify the missing number in a string of three numbers, which might appear at the first, middle, or last place (4 items each). In the *Numerical Magnitude Comparison* task ($r = .94$), children were shown 10 pairs of numerals (e.g., 8 and 4) one by one and were asked to tell which numeral in each pair carried a larger numerical value. Last but not least, the *Addition* task ($r = .89$) contained six items (e.g., 1 + 2). In each item, children had to tell the sum of two numbers given orally. For the *Rote Counting* task, the score that could be obtained for each item was the number of correct numbers recited before an error was made. For the other five tasks, one score was given for each correct answer.

Procedure

Ethics approval was sought from the Survey and Behavioral Research Ethics Committee of the Chinese University of Hong Kong to launch this study. All testing materials were created in English and were translated to Cebuano by a native speaker with a psychology postgraduate degree. The translations were reviewed and revised by a native speaker and a professional writer for a Cebuano newspaper. Consent forms were read and signed by parents before testing. Trained Cebuano-speaking psychology graduates administered the measures in children's individual homes. Numeracy and literacy assessments were administered in counterbalanced blocks. Parents or guardians answered the parent questionnaire forms independently, or with reading assistance, if needed. Children were given snacks at the end of the session.

Results

Descriptive statistics

Table 1 presents the descriptive statistics for the observed continuous variables. The variables with non-normal distributions were transformed to z-scores for subsequent analyses. Table 2 shows the correlations among all variables under investigation. In general, all subtests of numeracy competence correlated with age, attendance to preschool, parental education, receptive language, expressive language, and home resources. Children's liking of numeracy activities was correlated with parental

Table 1. Descriptive statistics for all variables

Variables (max possible)	*M*	*SD*	Min	Max	Skewness	Kurtosis
1. Age in months (–)	51.11	10.09	33.00	71.00	0.09	−1.16
2. Parental education (–)	0.00	1.00	−1.72	2.92	0.50	−0.28
3. Income (–)	292.90	251.80	13.79	4000.00	6.90	82.21
4. Receptive language (20)	10.66	3.83	0.00	20.00	−0.45	−0.20
5. Expressive language (10)	2.80	1.84	0.00	10.00	0.67	0.25
5. Home activities (6)	4.07	1.35	1.00	6.00	−0.16	−1.15
6. Home resources (5)	2.45	0.99	1.00	5.00	0.77	−0.00
7. Self-efficacy (6)	5.39	0.75	2.00	6.00	−1.64	2.86
8. Perceived importance (6)	5.48	0.71	2.00	6.00	−1.74	3.06
9. Value of play (6)	5.28	0.86	1.50	6.00	−1.40	1.69
10. Liking of numeracy activities (6)	5.18	0.88	1.83	6.00	−1.13	0.84
11. Numeral identification (20)	2.26	4.26	0.00	20.00	2.14	4.25
12. Object counting (14)	2.97	4.25	0.00	14.00	1.19	−0.01
13. Rote counting (36)	6.32	7.92	0.00	36.00	1.82	3.80
14. Missing number (12)	0.61	2.00	0.00	12.00	3.86	15.22
15. Numerical magnitude (10)	1.76	3.09	0.00	10.00	1.44	0.51
16. Addition (6)	0.46	1.18	0.00	6.00	3.06	9.06

Note. The theoretical maximum scores for children's literacy abilities, numeracy competence, and parents' practices and attitudes per variable are shown in parentheses. There are no theoretical maximum scores for age in months, parental education, and family income.

education, receptive language, home activities, home resources, and the three types of parental attitudes.

Structural equation model for numeracy interest and numeracy competence

Next, the proposed model was tested, so as to investigate the relative contributions of age, gender, attendance to preschool, SES, literacy abilities, parents' practices, and parents' attitudes to numeracy interest and numeracy competence in children (i.e., the primary goal of the present study). To better capture the complex nature of the constructs and reduce distortions caused by measurement errors, most of the variables under investigation (excluding age, gender, attendance to preschool, and numeracy interest) were latent variables, and each of them was measured with more than one observed measurements.

The goodness-of-fit indices showed that the proposed model explained the data with a high χ^2 (df) value equalling 395.44 (121); thus, the ratio of the chi-square to the degrees of freedom was smaller than 5:1. CFI, GFI, NFI, AGFI, and CFI valued .97, .94, .96, .91, and .97 separately; the SRMR and RMSEA were equal to .045 and .058, respectively. Overall, the model fit indices indicated that the model fits the data well (Figure 2).

As predicted, the model demonstrated that for numeracy interest, only the paths from parents' practices and parents' attitudes were significant (ps $< .001$). These two family variables altogether accounted for 49.5% of the variance in children's numeracy interest. On the other hand, for numeracy competence, only the paths from children's gender, age, SES, and literacy abilities were significant (for gender, age, and SES, ps $< .01$; for literacy abilities, $p < .001$). These four individual variables totally explained 48.3% of the variance

Table 2. Correlations among all variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Gender	–																		
2. Age	−.02	–																	
3. Preschool	−.01	.40***	–																
4. Parental education	−.05	−.10*	.15***	–															
5. Income	−.00	−.02	.05	.28***	–														
6. Receptive language	−.08	.45***	.34***	.15***	.04	–													
7. Expressive language	−.16***	.42***	.29***	.13***	.09*	.49***	–												
8. Home activities	−.05	−.05	−.03	.13***	.03	.05	.08*	–											
9. Home resources	−.04	.11**	.11**	.13**	.04	.16***	.21***	.27***	–										
10. Self-efficacy	.03	−.00	.03	.12**	.10*	.07	.05	.21***	.13***	–									
11. Perceived importance	.03	−.04	.04	.16***	.10*	.06	.04	.19***	.10**	.65***	–								
12. Value of play	−.02	−.04	.02	.15***	.07	.01	.02	.26***	.02	.59***	.64***	–							
13. Liking of numeracy activities	.03	.01	.06	.16***	.04	.11**	.07	.40***	.13***	.50***	.54***	.53***	–						
14. Numeral identification	−.09*	.39***	.24***	.20***	.15***	.37***	.51***	.09*	.23***	.07	.06	.03	.10**	–					
15. Object counting	−.03	.53***	.30***	.14***	.07	.44***	.52***	.06	.21***	.05	.02	.02	.08*	.72***	–				
16. Rote counting	.01	.45***	.29***	.18***	.07	.41***	.51***	.05	.17***	.01	−.02	−.05	.06	.65***	.73***	–			
17. Missing number	−.03	.34***	.18***	.14***	.10	.30***	.40***	.10**	.20***	.05	.04	.02	.09*	.73***	.58***	.61***	–		
18. Numerical magnitude	−.03	.28***	.18***	.14***	.10*	.23***	.37***	.09*	.17***	.02	.07	.00	.06	.59***	.49***	.48***	.58***	–	
19. Addition	−.01	.36***	.22***	.10*	.09*	.26***	.35***	.09*	.15***	.06	.01	−.00	.08*	.55***	.56***	.53***	.61***	.46***	–

Note. Gender: boys = 1, girls = 2. Preschool: no attendance to preschool = 1, attendance to preschool = 2. *$p < .05$; **$p < .01$; ***$p < .001$.

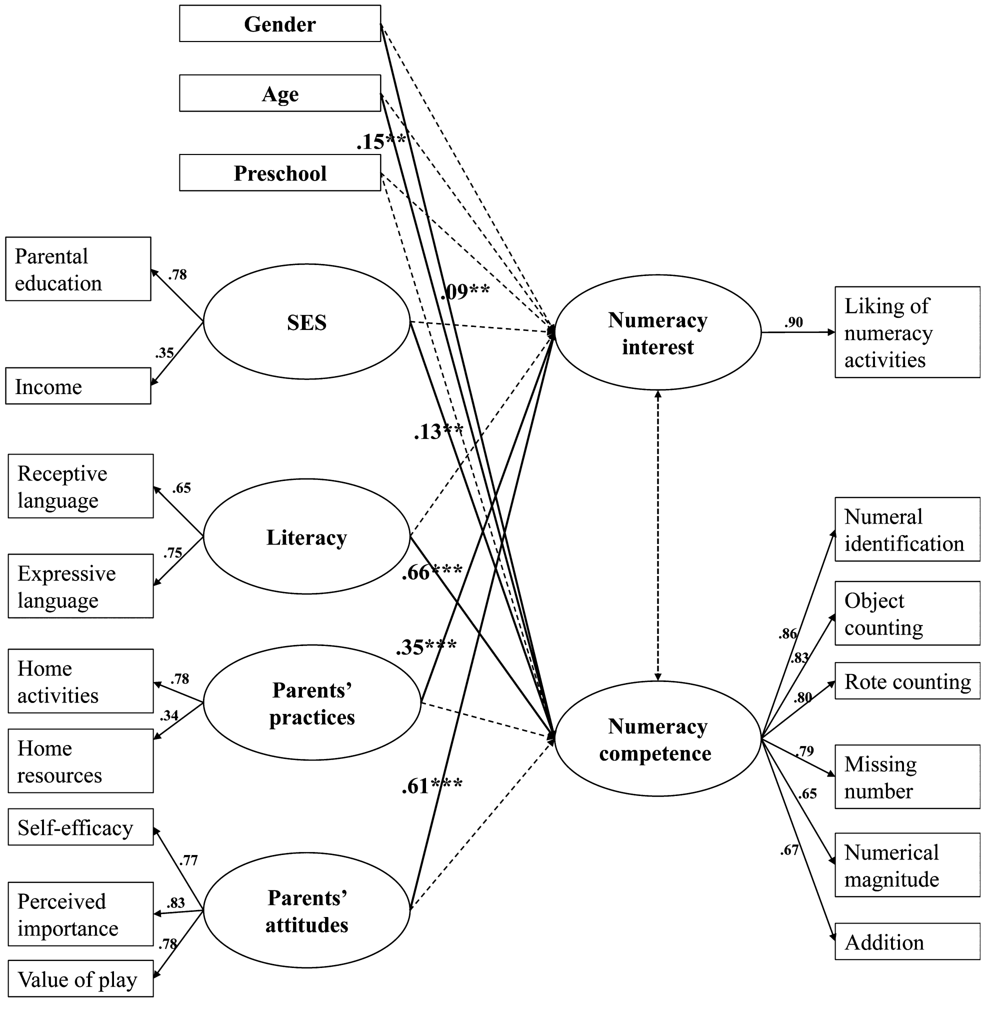

Figure 2. Structural equation modelling for numeracy interest and numeracy competence explained by gender, age, attendance to preschool, socioeconomic status (SES), literacy abilities, parents' practices, and parents' attitudes. Ellipses reflect latent variables, and rectangles indicate observed variables. Values showed on one-headed arrows from the latent to the observed variables are factor loadings in the measurement model, and values showed between the latent variables are regression coefficients between constructs. Solid lines reflect statistically significant relations, and dashed lines demonstrate non-significant relations. Gender: boys = 1, girls = 2. Preschool: no attendance to preschool = 1, attendance to preschool = 2. Interrelations among latent variables are shown in Table 3.

in numeracy competence. Different from our hypotheses, the paths from children's attendance to preschool, parents' practices, and parents' attitudes to children's numeracy competence were insignificant ($p > .05$). Moreover, there was no significant correlation between children's numeracy interest and competence ($p > .05$).

Table 3 showed the correlations among the latent variables accounting for numeracy interest and numeracy competence. To highlight, SES was related with children's literacy abilities, parents' practices, and parents' attitudes (ps < .001). These results were

Table 3. Correlations among gender, age, attendance to preschool, and other latent variables in the model accounting for numeracy interest and numeracy competence

Variables	1	2	3	4	5	6	7
1. Gender	–						
2. Age	−.02	–					
3. Preschool	−.01	.39***	–				
4. SES	−.05	−.11**	.18***	–			
5. Literacy abilities	−.18***	.61***	.43***	.25***	–		
6. Parents' practices	−.07	−.03	−.01	.22***	.17***	–	
7. Parents' attitudes	.02	−.03	.04	.24***	.07	.34***	–

Note. Gender: boys = 1, girls = 2. Preschool: no attendance to preschool = 1, attendance to preschool = 2. $^{**}p < .01$; $^{***}p < .001$.

generally consistent with correlations between the observed variables in Table 2 and clearly demonstrated the composite correlations between latent variables.

Discussion

The present study developed and tested a model explaining the numeracy interest and competence of disadvantaged young children in the Philippines. The findings made unique contributions to the existing literature about young children's numeracy development in several ways.

Home numeracy environment and numeracy development of disadvantaged Filipino children

In contrast to findings from previous studies conducted in the developed countries and our initial speculations, parents' practices and attitudes were only related to children's numeracy interest but not competence.

On the one hand, our findings provided support for the notion of Ruffell *et al.* (1998) that children's attitudes about mathematics are related to their experiences of carrying out mathematics tasks. Several possible explanations for this association can be put forward. First, when children are provided with many numeracy resources at home and frequently practice numeracy skills during everyday activities, they may appreciate more the value of mathematics. Second, when parents recognize their important role and feel confident in teaching children numeracy, they are likely to engage their children in home numeracy activities using a positive tone. Lastly, when parents endorse the value of play in early numeracy learning, they are more inclined to let children learn and practice numeracy skills through games. Nevertheless, it should be noted that the observed significant relations were correlational in nature. It is also possible that children who displayed high interest in numeracy elicited parents' positive attitudes towards teaching numeracy and more numeracy play at home.

On the other hand, the positive associations of parents' practices and attitudes with numeracy competence found in the correlational analyses disappeared when individual variables were considered using structural equation modelling. These findings contradict those of Melhuish *et al.* (2008), who found that the effect of home activities on British children's numeracy development appeared to demonstrate the largest effect size relative to SES and parents' education. This perhaps suggests that although the numeracy learning experiences created by parents in our disadvantaged sample might have been positive enough to elicit or address children's numeracy interest, these experiences might not have been effective enough in promoting or responding to children's numeracy competence. Indeed, Skwarchuk (2009) found that Canadian preschoolers' numeracy competence had positive relations only with participation in home activities with complex numeracy contents.

The present study has enhanced our understanding of the nature of the home numeracy environment of disadvantaged families in the Philippines and perhaps the context of other developing countries as well. As shown in Table 3, which depicted the relations among the latent variables in the final model, parents' attitudes towards early numeracy learning had a positive correlation with their home numeracy practices, and parents' attitudes and practices were positively correlated with SES. This suggests that the beliefs held by Filipino parents in our disadvantaged sample were generally aligned with their practices. Moreover, as for the context of developed countries (Starkey & Klein, 2008), within disadvantaged families, parents from relatively higher socioeconomic groups might also be more aware of the importance of home learning environment and the potential benefits of parent–child joint activities.

Roles of individual variables in the numeracy development of disadvantaged Filipino children

Similar to the context of developed countries, the present study showed that it is potentially important to consider the contributions of individual variables when examining the relation between home numeracy environment and young children's numeracy development.

Consistent with our hypotheses and the results of past studies (e.g., Jordan *et al.*, 2006), children's age, gender, SES, and literacy abilities were significant correlates of numeracy competence. Older children showed better numeracy competence. Surprisingly, a significant linkage between gender and numeracy competence that favoured girls was found in the final model. However, due to the correlational nature of the present study, it is unclear whether the age and gender-related differences were caused by more experiences in doing mathematics or some other factors.

When the effects of parents' practices and attitudes were statistically controlled, children from lower SES families still exhibited poorer numeracy competence. In other words, apart from the possibility of parents not taking on the responsibility of teaching at home and perhaps providing fewer learning resources, there were also some other disadvantages experienced by this group of children but not assessed in the present study. For example, children from lower SES families might have attended preschool programmes of lower quality. Moreover, parents who are less educated might be less competent in scaffolding their children's numeracy learning.

Among the four significant correlates of numeracy competence, children's literacy abilities had the greatest effect size. This likely occurred because, like understanding of print concepts and vocabulary, children were required to map to the number names the written numerals and the quantities they represented during numeracy tasks (e.g., numeral identification, numerical magnitude comparison, addition; Purpura & Napoli, 2015). Moreover, children with higher proficiency in literacy skills might better comprehend the task requirements of different numeracy tests (Purpura & Napoli, 2015).

Surprisingly, children in our sample who attended preschool did not show better numeracy competence. It happened perhaps because the quality of the preschool may not matter for children's early numeracy development (Melhuish *et al.*, 2008), and children in developing countries might not have access to quality education (Nag *et al.*, 2014).

Importance of studying both numeracy interest and competence

Children's academic interest, including numeracy interest, has been understudied in past literature (Fisher *et al.*, 2012). The present study demonstrated that in order to obtain a full picture of early numeracy development, it is essential to examine both its cognitive (i.e., numeracy competence) and affective (i.e., numeracy interest) dimensions. This is because young children's numeracy interest and competence might have different sets of correlates. Moreover, young children's numeracy interest and competence might be two rather distinct constructs. In the present study, in contrast to our hypothesis and results of previous studies (e.g., Lee & Kim, 2016), there was no significant correlation between young children's numeracy interest and competence. One possible reason is that the disadvantaged children in our sample who were interested in mathematics might not have had stimulating numeracy learning experiences. Given that early numeracy interest predicts future mathematical achievements (Fisher *et al.*, 2012), researchers and practitioners should pay more attention to numeracy interest, at least as much as numeracy competence.

Practical implications

First, intervention programmes should be arranged to help parents understand the home numeracy resources and activities they can offer to children so as to develop their more positive attitudes towards teaching numeracy skills at home. Such positive attitudes are important because parents' practices and attitudes are associated with young children's numeracy interest. Parents should also be introduced to ways in which to create high-quality home numeracy experiences, so that a positive linkage between home numeracy environment and early numeracy development can be formed.

In addition, educators and policymakers should pay special attention to the numeracy development of young children from low- to middle-income families, given that they are likely to fall behind their more affluent peers in numeracy competence. To reduce such a gap, more specifically targeted numeracy as well as literacy intervention programmes can be offered directly to these children as well. This is because the differences between socioeconomic groups are related to variables that are broader than variations in home numeracy environment, and proficiency in early literacy skills are related to better early numeracy outcomes.

Limitations and future directions

Despite its significance, the present study did have limitations. First, perhaps because of children's age and socioeconomic background, their scores on numeracy competence tasks were relatively low in the present study. Therefore, it was difficult to select enough number of children whose performances stay at a satisfying level for numeracy competence for further examination of the relations between home environment and numeracy competence.

Moreover, our participants came from low- to middle-income communities in Cebu only. To understand more fully the effects of SES on children's numeracy development, future studies could include families from more affluent communities of the city as well.

In addition, the present study only asked parents to report the frequency of children's engagement in numeracy activities and the amount of numeracy resources to which children were exposed at home. The quality of these home activities and resources, however, was not assessed. Future researchers could include observational measures to understand better the nature of home numeracy experiences created by different parents and take these effects into consideration when examining the relation between home numeracy environment and children's numeracy development.

Finally, the present study did not measure parents' attitudes towards mathematics as a subject area, which could include their enjoyment, fear, and perceived value of mathematics (Tapia & Marsh, 2004). As such attitudes sometimes are linked with children's numeracy development (Skwarchuk *et al.*, 2014), further studies could be carried out to investigate their direct effects on children's numeracy development, their indirect effects through an influence of the frequency of home numeracy activities, and their approaches to teaching children numeracy.

To conclude, the present study demonstrated that both family and individual variables played some roles in the numeracy development of disadvantaged young children in the Philippines. Training can be provided to help parents there create home environments that are more conducive to their children's numeracy learning.

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Appendix A
Items assessing parents' educational level, practices, attitudes, and children's numeracy interest in the parent questionnaire

Maternal (Paternal) educational level

1 = elementary level, 2 = elementary graduate, 3 = high school level, 4 = high school graduate, 5 = vocational graduate, 6 = college level, 7 = college graduate, 8 = professional/postgraduate degree.

Parents' practices – Home numeracy activities

(1 = never, 2 = rarely, 3 = once a week, 4 = several times a week, 5 = once a day, 6 = several times a day).

(1) Completing exercise books related to numbers
(2) Playing card games, board games, and/or computer games related to numbers
(3) Reading children's books related to numbers
(4) Talking about counting and practicing counting skills during everyday activities (e.g., cooking, shopping, travelling)
(5) Talking about number operations and practicing number operation skills (e.g., addition, subtraction) during everyday activities (e.g., cooking, shopping, travelling)
(6) Talking about the names and writing of numerals during everyday activities (e.g., cooking, shopping, travelling)
(7) Talking about the meaning of numbers (e.g., quantities represented by numerals, equivalence/non-equivalence of two or more sets of quantities, place value) during everyday activities (e.g., cooking, shopping, travelling)

Parents' practices – Home numeracy resources

(1 = none, 2 = 1–9 books, 3 = 10–29 books, 4 = 30–49 books, 5 = 50 books or above).

(1) Children's exercise books related to numbers

(2) Children's books related to numbers
(1 = none, 2 = 1–3 sets, 3 = 4–6 sets, 4 = 7–9 sets, 5 = 10 sets or above).
(3) Educational materials related to numbers (e.g., flashcards, number charts)
(4) Educational games related to numbers (e.g., board games, card games, and computer games)

Parents' attitudes – Self-efficacy in teaching young children numeracy

(1 = strongly disagree, 2 = moderately disagree, 3 = slightly disagree, 4 = slightly agree, 5 = moderately agree, 6 = strongly agree).

(1) I am probably more helpful to my child when it comes to his/her numeracy learning than other parents.
(2) I am sure my child knows I am interested in his/her numeracy learning.
(3) I am good at helping my child work through problems about numeracy learning.

Parents' attitudes – Perceived importance of parents' roles in early numeracy learning

(1 = strongly disagree, 2 = moderately disagree, 3 = slightly disagree, 4 = slightly agree, 5 = moderately agree, 6 = strongly agree).

(1) It is worthwhile for parents to teach their preschool children numeracy.
(2) Parents play an important role in preschool children's numeracy development.
(3) Parents need to teach their preschool children numeracy.
(4) It is important for parents to spend time in teaching their preschool children numeracy at home.

Parents' attitudes – Perceived value of play in early numeracy learning

(1 = strongly disagree, 2 = moderately disagree, 3 = slightly disagree, 4 = slightly agree, 5 = moderately agree, 6 = strongly agree).

(1) It is good for preschool children to learn about numbers through play because it can create happy learning experiences.
(2) Preschool children can learn numeracy skills by participating in games related to numbers.
(3) Compared to drill-and-practice method, it is better for preschool children to learn numeracy skills through play.
(4) Play is an important platform for preschool children to learn about numbers.

Children's numeracy interest

(1 = strongly dislike, 2 = moderately dislike, 3 = slightly dislike, 4 = slightly like, 5 = moderately like, 6 = strongly like).

(1) Counting objects
(2) Reciting number sequence
(3) Talking about numbers
(4) Participating in numeracy games
(5) Learning about numbers and operations
(6) Naming and writing numerals

Appendix B
Details about the difficulty level of items and ceiling level in each numeracy competence task

Numeral identification

(1) The first ten items involved numerals 1–10 in random order.
(2) The next five items involved numerals between 11 and 19 inclusive.
(3) The last five items involved numerals between 21 and 99 inclusive.
(4) The ceiling level was set at five consecutive errors.

Object counting

(1) The first five items involved 4–8 objects (in random order) that were placed in one or two lines.
(2) For the next three items, the number of objects fell between 4 and 9 inclusive but the objects were arranged in a circle.
(3) For the last six items, the number of objects ranged from 10 to 20 inclusive, and the objects were placed either in lines or randomly.
(4) The ceiling level was set at four consecutive errors.

Rote counting

(1) The first item involved recitation of number strings within 10.
(2) The second item involved recitation of number strings within 20.
(3) The third item involved recitation of number strings within 30.
(4) The last item involved recitation of number strings within 40.
(5) Testing stopped when children failed to recite all the numbers for an item.

Missing numbers

(1) The first six items involved number strings between 2 and 10 inclusive.
(2) The next three items involved number strings between 9 and 17 inclusive.
(3) The last three items involved number strings between 19 and 28 inclusive.
(4) The ceiling level was set at four consecutive errors.

Numerical magnitude comparison

(1) The first five items involved comparison of two single-digit numerals.
(2) The next two items involved comparison of one single-digit numeral and one two-digit numeral.
(3) The next three items involved comparison of two two-digit numerals.
(4) The ceiling level was set at three consecutive errors.

Addition

(1) The first two items involved answers within 5.
(2) The next two items involved answers within 10.
(3) The last two items involved answers within 15.
(4) The ceiling level was set at three consecutive errors.