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Parental facilitation of early mathematics and reading skills and knowledge through encouragement of home-based activities

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ABSTRACT

Early experiences with mathematics and reading are important to the future academic success of children in the United States. The present longitudinal study examined the role of parent-provided experiences in giving young children basic foundations in mathematics and reading. Participants at Time 1 were 200 4- and 5-year-old children (100 boys, 100 girls; m_{age} = 4.48 years) and their parents from suburban areas. One year later, 97 children (46 boys, 51 girls; m_{age} = 5.88 years) participated again. At both time points, children's reading and mathematics abilities were assessed using the TERA-3 and the TEMA-2 respectively, and parents completed the Encouragement of Academic Skills in Young Children (EASYC) questionnaire. Factor analyses of the EASYC responses revealed three mathematics activities factors (at T1 and T2) and three reading activities factors. After child age, the strongest predictor of children's math and reading scores was T1 Formal Mathematics Activities (e.g., "practice adding and subtracting single-digit numbers"). Parent-provided reading activities significantly predicted reading scores concurrently, but parent-provided mathematics activities predicted both mathematics and reading scores concurrently and mathematics scores one year later.

1. Introduction

Early experiences with mathematics and reading are important to the future academic success of children in the United States (e.g., Bennett, Weigel, & Martin, 2002; Bowman, Donovan, & Burns, 2000; Duncan et al., 2007; Huntsinger, Jose, Larson, Krieg, & Shaligram, 2000; Snow, Burns, & Griffin, 1998). Research shows that children who enter formal schooling without foundational skills in literacy and numeracy continue to lag behind those who do have those skills (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004). Early mathematics competency is the strongest predictor of later mathematics achievement in elementary and middle school (Duncan et al., 2007). In addition, early mathematics competency has been shown to be a better predictor of later reading achievement than is early literacy competency (Duncan & Magnuson, 2011). Much research has focused on the influence of home environments and parental attitudes, while less attention has been given to what parents actually do to promote children's learning, particularly in mathematics. Thus, the present study was an in-depth investigation of the activities in which parents engage their young children in order to facilitate academic preparedness.

Two theories have guided the present study. First, Bronfenbrenner's bioecological systems theory (1979) has described the influence of proximal and distal systems on a child's social and academic development. The most proximal microsystems are the child's family and the child's early childhood program or school. These are both settings in which the child is directly involved and interactions take place between an adult (parent, teacher) and a child. Second, Vygotsky's sociocultural theory (1978) suggests that cognitive development occurs through social interactions between a more experienced partner (a mentor) and a less experienced partner (a child). To be optimal, the mentor's teaching should be directed toward the upper boundary of a child's *zone of proximal development.* Parents (and frequently, grandparents or older siblings) and early childhood teachers are children's usual early mentors.

The attitudes parents hold regarding their child influence parents' actions with their child. Both parental attitudes (including parental perceptions of their child's abilities and interest in academic areas) and the experiences in which parents engage with their child are significant to their child's academic development

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Table 1
Factor analysis of Time 1 parent-provided mathematics activities.

Parent-provided mathematics activity	Informal	Formal	Fine motor
	α = .83	α = .72	α = .62
Play with math toys	**.68**		
Read counting books	**.68**		
Math fingerplays and songs	**.66**		
Play made-up math games	**.57**		
Plays with puzzles	**.54**		
Count objects or pictures	**.46**		
Plays with blocks or construction toys	**.46**		
Watches TV or videos with math content	**.45**		
Play board and card games	**.44**		
I use math in everyday home routines	**.38**		
I place numbers around the house.	**.37**		
Add and subtract single-digit numbers		**.86**	
Taught him to add on fingers		**.52**	
Give math challenges in the car		**.51**	
Does math workbooks		**.45**	
Uses math software		**.35**	
Strings beads in a pattern			**.56**
Constructs using pattern or symmetry			**.52**
Practices writing numerals			**.46**
Fold or cut paper			**.42**
Enroll in Kumon Program			
Teach child to tell time			
Play with Tangrams			

Note. Extraction method: Principal Axis Factoring. Rotation Method: Obliminwith Kaiser Normalization.

(Bornstein & Cheah, 2006; Eccles, 1993). Many parents in the United States believe they can influence their children's cognitive development, and therefore, engage in experiences they believe will promote their child's academic competence. Bornstein and Cheah (2006, p. 19) explain that "parent-provided experiences affect children via different mechanisms of action, but tend to follow the principles of specificity and transaction". The *specificity principle* (Bornstein, 2002), says, in essence, that specific experiences provided by parents at specific time points influence specific facets of a child's development in specific ways. For example, when a parent reads age-appropriate books to his two-year-old child, the child will likely enjoy being read to and will ask for more. The *transaction principle* (Sameroff, 1983) states that an individual's characteristics shape his or her experiences, and reciprocally, that those experiences shape the characteristics of the individual through time. For example, the child's desire to listen to more stories read by a parent will lengthen a child's attention span and extend her appreciation of longer and more complex books over time. The parent will focus on developmentally realistic and appropriate experiences, which change as the child grows older and becomes more knowledgeable and more cognitively mature.

Following Bronfenbrenner's and Vygotsky's general principles and Bornstein's more specific framework, the present longitudinal study examined the role that parent-provided home experiences play in giving young children basic foundational skills in reading and mathematics. We sought to answer the question, "What types of home experiences positively influence a young child's mathematics and reading test performance?"

1.1. Parental early enrichment practices

In the last several decades, researchers have investigated the influence of parental practices which encourage reading and writing, but only recently have researchers begun to focus on parental contributions to mathematics (Anders et al., 2012). Consequently, parents have had more exposure to recommendations for parent-provided activities to influence their child's reading development than recommendations to influence their child's mathematics development (LeFevre et al., 2009). Over 15 years ago, researchers Huntsinger, Jose, Larson, 1998; Huntsinger, Jose, Liaw, & Ching, (1997) found that parents' formal (more direct and systematic) teaching of mathematics predicted their preschool and kindergarten children's mathematics performance concurrently and four years later. Skwarchuk, Sowinski, and LeFevre, (2014) subsequently found that parents' formal home numeracy practices predicted children's symbolic number knowledge and that informal (more spontaneous and playful) home numeracy practices predicted non-symbolic arithmetic performance. Other research has supported the finding that parents' home numeracy practices are related to children's numeracy outcomes (e.g., Kleemans, Peeters, Segers, & Verhoeven, 2010; LeFevre et al., 2009).

Several instruments to assess the home learning environment have been developed in the last 30 years. The Early Childhood Home Observation for Measurement of the Environment (EC-HOME; Caldwell and Bradley, 1984) has been very useful in examining the factors in children's homes which foster thinking and learning (e.g., Son and Morrison, 2010; Totsika & Sylva, 2004). The broad-gauged measure of home environment, provided by the HOME, consists of a home observation and interview and includes 55 items assessing learning materials, language stimulation, physical environment, parental responsiveness, academic stimulation, modeling, variety, and acceptance. A short form (HOME-SF; Baker, Keck, Mott, & Quinlan, 1993) has predicted reading and mathematics scores in large, diverse samples of young children (Bradley, Corwyn, Burchinal, McAdoo, & Garcia-Coll, 2001). Because the HOME-SF is a broad-gauged measure, it includes only one four-part question regarding parental teaching: 'Circle the things that you or another adult are helping or have helped your child to learn here at home [Numbers, The Alphabet, Colors, Shapes, and Sizes]' (Bradley, Corwyn, McAdoo, & Garcia-Coll, 2001). The parental teaching variable did not predict children's math scores and was only weakly predictive of reading scores in the Bradley et al., (2001) study. The parental teaching question on the HOME-SF does not measure how frequently children experience parental teaching and does not describe the methods parents use to foster mathematics and reading skills and knowledge. While the HOME-SF has solid psychometric properties and has been found to predict later performance on tests in the academic domain, we argue that it may be useful in the literature to have a finer-gauged instrument to assess parent-provided learning activities.

Some existing self-report measures (e.g., Griffin & Morrison, 1997) inquire about the availability of literacy materials and the frequency of parents' reading to their children, but they do not reflect other things parents *actually do* with their children to facilitate the development of mathematics and literacy knowledge and skills. Other measures (e.g., Sy, Fan, & Huntsinger, 2003) ask whether parents have (or have not) taught their children letters of the alphabet, reading words, reading sentences, knowing numbers, adding, and writing their own name. However, assessments of this type are somewhat ambiguous. For example, does "knowing numbers" mean recognizing numerals or matching quantity with numeral or counting meaningfully? In addition, the nature or frequency of the parental teaching is not tapped.

In this vein, Fantuzzo, Tighe, and Childs (2000) developed the Family Involvement Questionnaire, with one of the factors being Home-Based Involvement. Home-Based Involvement describes 13 activities, which focus on "providing a place in the home for learning materials, actively initiating and participating in learning activities at home with children, and creating learning experiences for children in the community" (p. 371). One item specifically addresses working with the child on reading and writing skills and one item specifically addresses working with the child on number skills, with frequency of activity assessed on a 4-point Likert scale.

Miller, Farkas, Vandell, and Duncan (2014) used 10 pre-academic stimulation activities items (e.g., "helping their child with letters, numbers, and words" and "talking about size with their child") to measure effects of Head Start parents' teaching. The possible item responses were constrained to *yes* or *no*, which the authors acknowledged as "a limited measure of pre-academic stimulation.Ťhey also stated that the mathematics test they used, the *Woodcock-Johnson Applied Problems Test*, may not have been comprehensive enough to show effects.

Sénéchal and LeFevre (2002) have developed a Home Literacy Model which includes two components: (1) parent reports of how frequently they taught their children to read and print words and (2) parents' storybook exposure. Two pathways have been shown to link children's early literacy experiences to their early literacy skills. One pathway showed that children's exposure to shared reading with parents (informal experiences) correlated with children's scores on the vocabulary measure (PPVT) and indirectly correlated with reading ability in grades 2–4. The second pathway showed that direct parental teaching of specific early literacy skills (formal literacy experiences) predicted children's knowledge of the alphabet and word reading in all school grades.

Other studies (Blevins-Knabe, Berghout-Austin, Munson-Miller, Eddy, & Jones, 2000; LeFevre et al., 2009) have found that parents report using literacy activities more frequently than numeracy activities with their children at home. In regard to the numeracy domain, LeFevre et al., found that parent reports of home-provided numeracy activities were correlated with children's mathematics performance. The activities fell into two broad categories: direct activities for teaching specific skills, such as counting; and indirect activities that have numerical components embedded, but which do not involve direct teaching of numerical skills, such as playing board or card games. The frequency of child participation in indirect activities at home was related to children's mathematics proficiency.

Recently, Skwarchuk et al. (2014) created a Home Numeracy Model based on Sénéchal and LeFevre (2002) Home Literacy Model. To measure formal home literacy and home numeracy practices of parents of kindergartners, they created an 11-item home literacy measure and a 13-item home numeracy measure. To measure informal mathematics practices, they created a list of children's number games, similar to the list of children's book titles they used in their previous literacy measure (Sénéchal & LeFevre, 2002). Operating on the assumption that it may take a year before parental teaching efforts show an influence on children's academic development, children were evaluated on vocabulary, symbolic number knowledge, non-symbolic arithmetic, letter word reading, phonological awareness, and visual-spatial working memory a year after parents completed their reports. Domain-specific items were used to predict numeracy and literacy outcomes. The authors found that advanced formal literacy practices (a two- item scale) predicted letter word reading, and informal literacy practices (a three-item scale) uniquely predicted children's vocabulary. Parents' numeracy attitudes directly predicted both of the numeracy outcomes. Parents' informal numeracy practices (a four-item scale) predicted children's non-symbolic arithmetic, while parents' formal numeracy practices (a four-item scale) predicted children's symbolic number knowledge.

In summary, existing research regarding parent contributions to their young children's literacy is much more plentiful than research devoted to numeracy. Fortunately, in the last decade, the focus on mathematics development has increased. That literature shows that parent-provided experiences do influence children's mathematical development. Although researchers have created measures to assess parental encouragement of activities, several of the previously described measures seem to have shortcomings. In some, the response options are binary, providing no indication of the frequency of parent-provided experiences. In others, the meaning of the items is ambiguous or the items are too general, so that the results cannot provide specific guidance to parents who are searching for ways to enhance their child's academic development. Our new measure, similar to most measures, consists of domain-specific items to predict early mathematics or reading. However, because early mathematics ability has been found to be the best predictor of both future mathematics success (Duncan et al., 2007) and later reading achievement (Duncan & Magnuson, 2011), we believe that it is useful to investigate the influence of parent-provided activities across both domains. In this vein, Purpura, Hugh, Sims, and Lonigan (2011) presented evidence for an important link between early literacy and early numeracy in young children. They found that print knowledge and vocabulary accounted for unique variance in the prediction of children's numeracy scores a year later. Austin, Blevins-Knabe, Ota, Rowe, and Lindauer (2011) suggest that teaching early numeracy skills as frequently as letter awareness skills might result in more efficient acquisition of both.

Recent research has revealed that both cognitive and linguistic skills predict children's early numeracy skills (Kleemans et al., 2010; Lefevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010). The Pathways model (LeFevre, Fast et al., 2010) proposes that numerical development involves three distinct pathways: linguistic, quantitative, and spatial attention, which contribute independently to the development of informal mathematical skills (embedded in everyday context) and formal mathematical knowledge (which is explicitly taught). Researchers generally agree that only the neural circuit involved in processing number magnitude (the quantitative pathway) is specifically devoted to numeric tasks (Butterworth, 2005; Castelli, Glaser, & Butterworth, 2006; Dehaene, Molko, Cohen, & Wilson, 2004). The linguistic and the spatial attention pathways, while involved in numerical tasks, are also utilized in a variety of other cognitive tasks. However, we know very little about the ways through which numerical or literacy processing or both may be facilitated by different activities.

1.2. The present study

Our main objective was to construct a measure that could gauge how specific experiences provided at home by parents (assessed through parental self-reports) may be related to their children's early reading and mathematics performance. We know that considerable overlap exists between children's performance on measures of early mathematics and early reading. Correlations between the two academic domains are generally very high (Matthews, Ponitz, & Morrison, 2009; Piasta, Purpura, & Wagner, 2010). There is some evidence that both literacy- and numeracy-focused home learning experiences are related to children's mathematics outcomes. Anders et al. (2012) found that broadly defined numeracy-related and literacy-related home learning experiences were related to children's early mathematics learning in Germany. LeFevre et al. (2009) found that a letter activities factor (printing, naming, and identifying sounds of alphabet letters) was correlated ($r = .21$) with children's math knowledge. Consequently, it is very likely that the influence of parents' practices with young children is not domain-specific. For example, when parents teach children to write numerals, the experience also probably supports children's learning to write alphabet letters, since both involve mastering symbol systems and developing fine motor coordination. Using ECLS-K data, Luo, Jose, Huntsinger, and Pigott (2010) found that fine motor skills predicted mathematics achievement over time. Similarly, children probably obtain some mathematics benefits (linguistic, math content, page numbers, sequence, number words) from listening to a story read by a parent or older sibling. Teachers of young children have long been focused on teaching the whole child (Lascarides & Hinitz, 2000), recognizing the overlap of skills in the early years.

Table 2
Factor loadings of T1 parent-provided reading activities.

	Factor 1 Comprehension $\alpha = .69$	Factor 2 Letters $\alpha = .82$	Factor 3 Words $\alpha = .69$	Factor 4 Library $\alpha = .45$
Play word-rhyming games	**.75**			
Point out words in the environment	**.72**			
I define (explain) new words.	**.67**			
I ask questions about the story.	**.35**			
Listen to stories read by family members.	**.31**			
Encourage proper letter formation		**.93**		
Does alphabet workbooks		**.81**		
Traces or copies words			**.93**	
Asks how to spell words			**.47**	
Practices writing name			**.46**	
I assign words to copy			**.34**	
Attends library story time				**.77**
Reads library books				**.59**
Belongs to book club				
Uses computer pre-reading software				

Notes. Extraction Method: Principal Axis Factoring. Rotation method: Oblimin with Kaiser Normalization.

Table 3
Factor loadings of Time 2 parent-provided mathematics activities.

Parent-provided mathematics activity	Formal	Informal	Games/Toys
	$\alpha = .77$	$\alpha = .67$	$\alpha = .68$
Add and subtract one-digit numbers	**.78**		
Give math challenges while riding in the car	**.65**		
Use math in everyday home routines	**.59**		
Use math computer software	**.46**		
Does math-related workbooks or worksheets	**.42**		
Practice writing numerals	**.40**		
Play made-up math games	**.38**		
Add small quantities on fingers	**.35**		
Watches TV shows or videos that teach math	**.31**		
Math-related songs and fingerplays		**.75**	
Reads counting books		**.74**	
Counts objects		**.54**	
Strings beads in a pattern		**.45**	
Uses patterns or symmetry		**.38**	
Does paper folding or cutting		**.35**	
Plays with blocks or construction toys			**.65**
Plays with math toys			**.55**
Plays board or card games			**.54**
Plays with puzzles			**.48**
Plays with Tangrams			**.30**

Notes. Extraction Method: Principal Axis Factoring. Rotation method: Oblimin with Kaiser Normalization.

Because parents play a major role in providing enriched environments for their young children, we developed a new measure titled Encouragement of Academic Skills in Young Children (EASYC) after conducting in-depth interviews of parents regarding the methods they use to facilitate mathematics and reading development in their young children, as reported in previous research (Huntsinger et al., 1997, 1998, 2000). We included items that assess both formal (deliberate teaching) and less formal (embedded in everyday context) parental methods in the two domains of reading and mathematics.

Our primary aim was to assess the utility of our newly developed EASYC questionnaire as a predictor of young children's mathematics and reading development. As part of that process we needed to (a) assess the early mathematics and reading development of the 4–6-year-old children in our study, (b) determine what literacy and mathematics experiences parents afford their young children; and last, (c) explore the links between reports of parent-provided mathematics and literacy experiences and children's performance on tests of early mathematics and reading concurrently and longitudinally. Based on previous research findings, we expected that parent-provided mathematics activities would predict children's mathematics scores concurrently and a year later. We expected that parent-provided reading activities would predict reading scores concurrently and may also predict reading scores a year later. Based on the research of Anders et al. (2012) and LeFevre et al. (2009), we also expected that parent-provided mathematics activities would predict reading scores of the young children.

2. Method

2.1. Participants

At Time 1, the sample (79% European American; 13.5% Asian American; 3% African American; 4% Latino) comprised 200 children ($m_{\text{age}} = 4.99$ years.; 100 boys, 100 girls) and their parents from middle class suburbs near Chicago and Philadelphia. The vast majority of children (88%) had two adults in the home, 6.5% had one adult, 2.5% had three adults, and 3% had four adults. Regarding school enrollment, 156 of the children were enrolled in preschool programs, and 44 children were in kindergarten. Initially, we chose children based on age rather than U.S. grade level[1] to enable us to compare the United States results with results using the same measures in New Zealand in a companion study (see Munro, Jose, & Huntsinger, 2015). However, in the end, large cultural and schooling differences led us not to compare the two countries.

At Time 2 (one year later), 48.5% of the U.S. children participated. Attrition was chiefly due to inability to find and re-contact families. Children had scattered from the private preschools and child care centers near their parents' workplaces into many different public school kindergartens and first grades nearer their homes. The smaller Time 2 sample was very similar to the larger Time 1 sample in most respects (e.g., early mathematics and reading scores). The only statistically significant difference was that Time 2 participants were 2 months younger than Time 2 non-participants. At Time 2 our sample ($m_{age} = 5.88$ yrs; 46 boys, 51 girls) consisted of 43 preschoolers, 36 kindergartners, and 18 first graders. It is important to note that these children were younger than children in studies by Skwarchuk, LeFevre, and Sénéchal.

Children were initially recruited from kindergartens in two public schools (one was a charter school), five child care cen-

[1] In New Zealand, children start Year 1 (kindergarten) on their 5th birthday, whereas to begin kindergarten in the states of Pennsylvania and Illinois, children are required to be 5 years old by September 1 of the school year. This fact means that U.S. children with September and October birthdays are nearly 6 years old when they begin kindergarten.

Table 4
Factor loadings of Time 2 parent-provided reading activities.

T2 Parent-provided reading activity	Factor 1 Comprehension $\alpha = .74$	Factor 2 Letters/Words $\alpha = .72$	Factor 3 Library $\alpha = .57$
I point out words in the environment	.66		
Traces or copies words	.62		
Practices writing name	.58		
I define (explain) new words	.52		
Play word-rhyming games	.51		
I ask questions about the story	.39		
Encourage proper letter formation		.86	
Does alphabet workbooks		.78	
Uses pre-reading computer software		.37	
I assign words to copy		.33	
Reads library books			.92
Attends library story time			.47
Belongs to book club			
Listens to stories read by family members			

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

Table 5
Mean raw scores (and SDs) in reading and mathematics and parents' ratings at Times 1 and 2.

Measure	Time 1 $N = 200$	Time 2 $N = 97$
TERA-3 (Reading)	33.18 (10.35)	47.89 (12.56)
Alphabet Raw	15.81 (6.08)	21.92 (4.16)
Conventions Raw	7.89 (3.61)	12.57 (3.59)
Meaning Raw	9.48 (2.67)	13.40 (6.53)
TEMA-2 (Mathematics)	23.77 (8.14)	36.04 (10.36)
Informal Math	19.62 (5.58)	26.62 (4.61)
Formal Math	3.85 (2.45)	9.39 (6.24)
Like reading/writing[a]	4.41 (.83)	4.44 (.75)
Ability in reading/writing[b]	3.47 (.91)	3.73 (.88)
Like mathematics[a]	4.17 (.90)	4.42 (.79)
Ability in mathematics[b]	3.64 (.88)	3.93 (.77)

[a] Indicates parent report of child's like of reading/writing and mathematics rated on a scale from 1 = *not at all* to 5 = *very much*.
[b] Indicates parent report of child's ability in reading and mathematics rated on a scale from 1 = *poor* to 5 = *excellent*.

ters with preschool and kindergarten classes, and two preschools without kindergartens. Four of the preschool sites were NAEYC-accredited, which indicates high-quality programs. Six of the seven preschool sites had directors with masters' degrees in early childhood education, which also suggests high quality. The public school kindergartens served children in middle- to upper middle-class neighborhoods. The informal observations of the three research assistants (all held master's degrees and were former teachers of young children) who assessed the children in the schools support the view that the preschools and kindergartens were of high quality.

Most of the children participated in organized extracurricular activities in addition to preschool or kindergarten. At Time 1, 22% participated in music, 63% in sports, 10% in art, 29% in dance, 29% in religion-based classes, and 13% in library programs. At Time 2, 23% participated in music, 73% in sports, 21% in art, 37% in dance, 35% in religion classes, and 15% in library programs.

2.2. Materials

The following materials were used at both Time 1 and Time 2:

2.2.1. Test of early mathematics ability-second edition (TEMA-2)

We used the TEMA-2 (Ginsburg & Baroody, 1990), designed for use with children from 3 to 8 years of age, to assess both informal (35 items) and formal (30 items) mathematical thinking. Informal mathematics, acquired outside the context of formal schooling, is assessed by three types of items: concepts of relative magnitude, counting, and calculation. Formal mathematics, learned through explicit instruction using rules, principles, and procedures, is assessed by four types of items: knowledge of convention, number facts, calculation (addition and subtraction), and base-ten concepts. The highest possible score is 65. The TEMA-2 has demonstrated high internal reliability ($\alpha = .94$) and test–retest reliability ($r = .94$; Ginsburg & Baroody, 1990).

2.2.2. Test of early reading ability-third edition (TERA-3)

We used the TERA-3 (Reid, Hresko, & Hammill, 2001), designed for use with children 3 1/2 to 8 1/2 years of age, to assess mastery of early-developing reading skills. It is composed of three subtests: alphabet (29 items), which measures knowledge of the alphabet and the sounds associated with letters and letter combinations; conventions (21 items), which measures knowledge of the conventions of print; and meaning (30 items), which measures a wide variety of ways in which a child comprehends print or the construction of meaning from print. The child receives one point for each correct answer; the highest possible score is 80. The TERA-3 has demonstrated high internal reliability ($\alpha = .95$) and test–retest reliability ($r = .98$; Reid et al., 2001).

2.2.3. Parent questionnaire

Parents completed questions regarding demographic information, their child's school enrollment, extracurricular activities, computer use, ratings of their child's liking of mathematics and reading, ratings of their child's reading and mathematics ability, and how far their child could count. Nine items, assessing magazine and newspaper subscriptions, library use, child's television viewing, and book reading from Griffin and Morrison (1997) Home Literacy Environment measure, were also included.

2.2.4. Parents' ratings of children's liking of and their abilities in math and reading

Parents were asked the following questions: 'How much does your child like counting and mathematics-related activities?änd "How much does your child like stories and writing activities?Ësponse choices were made on a Likert scale where 1 = *not at all* and 5 = *very much*. Parents also responded to the following questions regarding their child's ability in reading and writing and mathematics: "How would you rate your child's reading and writing abilities (compared to other similar-aged children) ?änd "How would you rate your child's mathematics abilities (compared to other similar-aged children) ?' Responses were given on a 5-point Likert scale where 1 = *poor* and 5 = *excellent*. Parents also answered the open-ended question, "How far can your child count?̈Responses varied from 4 to 1000 at T1 and from 15 to 1000 at T2. Eighty-five percent of the parent data was completed by mothers, 13.5% was completed by fathers, and 1.5% was completed jointly by both parents.

2.2.5. Encouragement of academic skills in young children (EASYC)

This questionnaire was developed specifically for the present study. All the items were derived from methods that parents had named in response to two open-ended questions: "What do you do to facilitate your child's acquisition of reading?änd "What do you do to facilitate your child's acquisition of mathematics?̈in interviews conducted in previous research (Author et al., 1997; 1998; 2000). In the EASYC measure, ten items which assessed to what extent the parents currently do specific things (i.e., "Give our child math challenges while traveling in the car") were rated using a 3-point Likert scale where 1 = *never do it*, 2 = *sometimes do it,* and 3 = *do it a lot*. Four items, which assessed whether parents had ever done the action (i.e., "Join a children's book club") were rated *Yes* or *No*. Twenty-eight items assessed how often the child does each of the following activities at home (i.e., "Does math-related workbooks and worksheets") and were rated on a 4-point Likert-type scale where 1 = *never*, 2 = *occasionally*, 3 = *often*, and 4 = *very often*. Regardless of whether an item was scored on a binary, 3-point, or 4-point rating scale, we summed the item ratings for each factor used in the regressions. However, only one of the binary items loaded on a factor. (See the Appendix for the full questionnaire.) The EASYC demonstrated high internal consistency (a = .86). Test–retest reliability over a one-week period, using an ad hoc group of 26 parents of 4- and 5-year-olds who did not participate in this study, was high (ICC(3,k) = .91; Howell, n.d.).

2.2.6. Age of child and gender influences

At Time 1 some children were in preschool and some were in kindergarten. At Time 2, some children were in preschool, some were in kindergarten, and some were in first grade. As children get older, they are enrolled in successively higher levels of schooling, containing increasingly higher levels of organized mathematics and reading instruction, which likely contribute to children's reading and mathematics test scores. We used child's age in months in our regressions, expecting that older children would obtain higher scores than younger children, who would have had less exposure to structured school curriculum in mathematics and reading.

We also included gender of child in our regressions, even though gender differences in early childhood numeracy and literacy have not often been found (e.g., Clements and Sarama, 2008; Lachance & Mazzocco, 2006). One exception is research on spatial skills. Several researchers (Levine, Huttenlocher, Taylor, & Langrock, 1999; McGuinness & Morley, 1991) have found early childhood gender differences in spatial ability, specifically, boys are more accurate in spatial transformation tasks by the age of 4 1/2 and boys from the age of 4 years are more likely than are girls to use spatial strategies for solving problems. Coley (2002) reported that in the ECLS-K study, girls had a small advantage in recognizing numbers and shapes, whereas, boys performed somewhat better in numerical operations. However, Halpern et al. (2007) report that the small sex difference in math abilities in elementary school favors girls. Regarding reading, Halpern et al. (2007) report that the female advantage in reading is international.

2.3. Procedure

At Time 1, invitations to participate in the study and consent forms were distributed to the parents of children in early childhood programs and kindergartens in suburban Illinois and Pennsylvania communities. At Time 2 letters were mailed to parents asking for their continued participation. Logistical considerations at Time 2 dictated that we confine testing to schools which had at least 4 children from the Time 1 data collection enrolled. At Time 1 and Time 2 each child was individually given the Test of Early Mathematics Ability-2 (TEMA-2; Ginsburg & Baroody, 1990) and the Test of Early Reading Ability-3 (TERA-3; Reid et al., 2001) on two different days in a quiet room at their center or school. Parents completed the EASYC questionnaire at home and mailed their surveys back to the researchers. Within one month of completing the Time 1 child assessments, an individual letter containing detailed feedback regarding the child's mathematics skills and knowledge and the child's TEMA-2 and TERA-3 scores was mailed to the parents of each child.

2.4. Preliminary analyses

We separated the items that represented mathematics-related parent-provided activities (23 items) from the activities that represented reading-related parent-provided activities (15 items). Four items which were not specific to math or reading (e.g.,"I tell my child that it is important to do well in school.̈) were excluded. Then we performed Principal Axis Factoring (Rotation method: oblimin with Kaiser normalization) on the items in each domain.

2.4.1. Time 1 factor analyses

The Time 1 factor analysis of 23 mathematics-related activities (see Table 1) revealed that a 3-factor solution was the best fit for the data: Factor 1 was named Informal Math Activities (11 items, α = .83); Factor 2 was named Formal Math Activities (5 items, α = .72); and Factor 3 was named Fine Motor Activities (4 items, α = .62).

The Time 1 Factor analysis of the 15 reading items (see Table 2) revealed that a four-factor solution was the best fit for our data. Three of the factors yielded acceptable alphas: Comprehension Activities (5 items, α = .69); Word Activities (4 items, α = .69); and Letter Activities (2 items, α = .82). The fourth factor, Library Activities (2 items, α = .45) was not used in the regressions.

2.4.2. Time 2 factor analyses

Because parents change the activities that they do with their children as their children learn and mature, we believed the factor structure would be somewhat different a year later at Time 2. Factor analysis of the 23 mathematics-related activities revealed that a three-factor solution was again the best fit for the data (see Table 3). Factor 1 was named Formal Math Activities (9 items, α = .77); Factor 2 was named Informal Math Activities 6 items, α = .67: and Factor 3 was named Games, Blocks, and Toys (5 items, α = .68).

Factor analysis of the 15 Time 2 reading-related items resulted in a three-factor solution (see Table 4): Factor 1 was named Comprehension Activities (6 items, α = 74); Factor 2 was named Letter/Word Activities (4 items, α = .72); and Factor 3 was named Library Activities (2 items, α = .57). The low alpha for Factor 3 precluded its use in the regressions. Factor structures were similar, but not identical between Time 1 and Time 2.

3. Results

3.1. Children's early mathematics and reading achievement

The children's Time 1 and Time 2 mean scores on the TEMA-2 and TERA-3 and all subtests are displayed in Table 5. Scores at Time 2 were higher, as expected. No mean gender differences were found on the TEMA-2 and TERA-3 raw scores or subtest scores at Time 1.

Table 6
Intercorrelations among tests of early reading and early mathematics at Times 1 and 2.

	1.	2.	3.	4.	5.	6.	7.
1. Alphabet raw score	1	.645	.388	.913	.748	.743	.679
2. Conventions raw score	.676	1	.463	.848	.717	.697	.645
3. Meaning raw score	.610	.679	1	.648	.416	.364	.371
4. TERA-3 raw score	.841	.862	.915	1	.797	.774	.720
5. TEMA-2 raw score	.726	.673	.729	.811	1	.919	.861
6. Informal math score	.739	.678	.613	.756	.930	1	.847
7. Formal math score	.654	.612	.752	.782	.963	.796	1

Notes. All correlations are significant at the $p = .0001$ level. Time 1 correlations appear above the diagonal. Time 2 correlations appear below the diagonal.
Time 1 $N = 200$; Time 2 $N = 97$.

Table 7
Correlation matrix of study variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. TEMA T1	1	.87***	.80***	.86***	.64***	.03	.00	.40***	.17*	.13	−.17	.15	−.02	.23**	.09	−.10	−.16	.16
2. TEMA T2	.87***	1	.80***	.81***	.65***	.26*·	.09	.50***	.13	.21*	−.14	.27**	.12	.15	.01	−.10	−.10	.17
3. TERA T1	.80***	.80***	1	.86***	.65***	.04	.03	.43***	.20*	.22*	−.06	.14	.12	.36**	.16*	.01	−.01	.20*
4. TERA T2	.86***	.81***	.86***	1	.65***	.03	−.01	.40***	.12	.16	−.11	.15	−.02	.21*	.10	−.01	−.01	.22*
5. Age in months	.64***	.65***	.65***	.65***	1	.20**	−.09	.20**	.00	.02	−.15	.09	−02	.12	.01	−.17	−.11	.20
6. Gender	.03	.26*	.04	.03	.20**	1	.04	.07	−.24**	−.03	−.41	.12	.01	−.14	−.04	−.18	−.09	−.14
7. T1 Informal math activities	.00	.09	.03	−.01	−.09	.04	1	.45**	.44**	.42**	.51**	.51**	.61***	.38**	34**	.47**	.40**	.01
8. T1 Formal math activities	.40**	.50***	.43**	.40**	.20**	.07	.45***	1	.37***	.45***	.03	.19	.33***	.38***	.36***	.19	.24*	−.01
9. T1 Fine Motor activities	.17*	.13	.20**	.12	.00	−.24**	.44***	.37**	1	.22*	.44**	.29**	.28**	.52***	.34**	.28**	.29**	.08
10. T2 Formal math activities	.13	.21*	.22*	.16	.02	−.03	.42**	.45**	.22*	1	.46**	.44**	.31**	.34**	.30**	.61***	.58***	.13
11. T2 Informal math activities	−.17	−.14	−.06	−.11	−.15	−.40**	.51***	.03	.44***	.46***	1	.32***	.28**	.31**	.18	.62***	.49***	.31**
12. T2 Board games, blocks	.15	.27**	.14	.15	.09	.12	.51***	.19	.29**	.44***	.32**	1	.28**	.25*	.26**	.35**	.40***	.20*
13. T1 Compre- hension activities	−.02	.12	.12	.02	−.02	.01	.61***	.33**	.28**	.31**	.28**	.28**	1	.35***	.22**	.54***	.16	.01
14. T1 Word activities	.23**	.14	.36***	.21*	.12	−.14	.38***	.38***	.52***	.34**	.31**	.25*	.35***	1	.44***	.40**	.32**	−.20
15. T1 Letter activities	.09	.01	.16*	.10	.01	−.04	.34**	.36***	.34***	.30**	.18	.26**	.22**·	.44**	1	.29**	.51***	−.11
16. T2 Compre-hension activities	−.10	−.10	.01	−.01	−.17	−.18	.47***	.19	.28**	.61***	.62***	.35***	.54***	.40***	.29**	1	.43**	.10
17. Word/Letter activities	−.16	−.10	−.01	.01	−.11	−.09	.40***	.24*	.29**	.58***	.49***	.40***	.16	.32**	.51***	.43***	1	.20
18. Library activities	.16	.17	.20*	.22*	.20	−.14	.01	−.01	.08	.13	.31**	.20*	.01	−.20	−.11	.10	.20	1

Notes. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. Time 1 $N = 200$; Time 2 $N = 97$.
Gender: Girl = 0, Boy = 1.

3.2. Correlational analyses of TEMA-2 and TERA-3 scores

The Time 1 to Time 2 TEMA-2 correlation (i.e., stability coefficient) was very high: $r(97) = .87$, $p < .0001$. The stability coefficient for the TERA was also very high: $r(97) = .86$, $p < .0001$. In general, a child who performed well at Time 1 also performed well at Time 2.

As expected, at both Times 1 and 2, we found very high cross-domain correlations between the TEMA and TERA scores (see Table 6). Correlations were $r(200) = .80$, $p < .0001$ at Time 1 and $r(97) = .81$, $p < .0001$ at Time 2. These results indicate that a child who scored high on the mathematics test was likely to also score high on the reading test. Looking at Time 1 and Time 2 subtests across domains, we also found strong ($rs = .65–.92$) associations among the alphabet, conventions, informal mathematics, and formal mathematics subtests as well as the complete TERA-3 and TEMA-2. Associations between the TERA-3 meaning subtest and the other TEMA and TERA subtests were more moderate ($rs = .36–.42$) at Time 1, but stronger at Time 2 ($rs = .61–.75$).

3.3. Parent reports of child's liking of and ability in reading and mathematics, and counting skill

3.3.1. Liking of and ability in reading and mathematics

At Time 1 and Time 2 respectively, parents' reports indicated on a 5-point scale that their children liked reading/writing ($Ms = 4.41$, 4.44) and counting/mathematics ($Ms = 4.17$, 4.42) activities fairly well to very much (see Table 5). They rated their children's ability in reading/writing as average ($Ms = 3.47$, 3.73) and their ability in mathematics as average to very good ($Ms = 3.64$, 3.93).

3.3.2. Counting skill

Parents were asked at both time points, "How far can your child count?T̈he mean at Time 1 was 80 (SD = 140.95; median = 42; mode = 100). The Time 2 mean was 200 (SD = 285.62; median = 100; mode = 100).

Correlations between parent reports of how far the child could count and their children's mathematics performance were moderate to high: Time 1 rs (200) = .55, .37, and .46, $ps < .0001$; Time 2 rs (97) = .62, .48, and 67 for overall TEMA-2, informal, and formal raw scores, respectively. These results suggest that the parents' reports of their child's counting ability reflect their children's overall mathematics performance in the early years.

3.4. Associations among key variables

See Table 7 for correlations among key study variables.

3.5. Concurrent predictions of mathematics and reading at Time 1 and Time 2

3.5.1. Time 1 mathematics results

To assess the contribution of home activities to young children's mathematics and reading scores, we performed a series of hierarchical multiple regressions. In three separate regressions, we regressed the child's Time 1 overall TEMA-2 score and the two constituent scores (informal mathematics subtest, and formal mathematics subtest) on child age and child gender in the first step, and the three parent-provided math activities factors in the second step. Child age emerged as a strong predictor in all three regressions (see Table 8), while child gender was not a significant predictor.

Table 8
Concurrent predictors of Time 1 TEMA scores and subtest scores.

Child outcome	Predictors	$\sum R^2$	R^2 chng	β	ρ
T1 TEMA Score		.499			
	Step 1: Age in months		.403	.561	.0001
	Step 2 Informal math activities		.096	−.145	.019
	Fine motor activities			.117	.045
	Formal math activities			.308	.0001
T1 Informal score		.422			
	Step 1: Age in months		.311	.501	.0001
	Gender		.014	−.121	.103
	Informal math activities		.097	−.140	.037
	Fine motor activities			.102	.122
	Formal math activities			.319	.0001
T1 Formal score		.402			
	Step 1: Age in months		.270	.427	.0001
	Step 2: Informal math activities		.132	−.191	.005
	Fine Motor activities			.106	.095
	Formal Math activities			.383	.0001

Note. Gender is scored 0 = girls and 1 = boys.

Table 9
Concurrent predictors of Time 1 TERA score and subtest (Alphabet, Conventions, and Meaning) scores.

Child outcome	Predictors	$\sum R^2$	R^2 chng	β	ρ
T1 TERA Score		.503			
	Step 1: Age in months		.419	.616	.0001
	Step 2: Letter activities		.084	.035	.534
	Word activities			.259	.0001
	Comprehension activities			.036	.504
T1 Alphabet score		.362			
	Step 1: Age in months		.272	.484	.0001
	Step 2: Letter activities		.090	.056	.379
	Word activities			.287	.0001
	Comprehension activities			−.048	.436
T1 Conventions score		.506			
	Step 1: Age in months		.436	.625	.0001
	Step 2: Letter activities		.070	−.086	.130
	Word activities			.291	.0001
	Comprehension activities			.007	.893
T1 Meaning score		.258			
	Step 1: Age in months		.182	.436	.0001
	Step 2: Letter activities		.076	.123	.075
	Word activities			−.046	.530
	Comprehension activities			.239	.0001

Older children scored higher on the TEMA and informal and formal math subtests. In the first regression, Informal Math Activities, Fine Motor Activities, and Formal Math Activities significantly predicted the T1 overall TEMA-2 score. In the second and third regressions, both Informal Math Activities and Formal Math Activities predicted the T1 informal math subtest and formal math subtest scores. However, the correlations for Informal Math Activities were negative in all three regressions. Parents who reported less frequent use of informal and more frequent use of formal mathematics activities and fine motor activities had children who scored higher on the overall TEMA. Children, whose parents reported less frequent use of informal and more frequent use of formal math activities, scored higher on both the informal and formal subtests of the TEMA.

3.5.2. Time 1 reading results

Next we performed four similar regressions, in which we regressed the child's Time 1 overall TERA score and the three constituent scores, (alphabet subtest, conventions subtest, and meaning subtest) on child age and child gender in the first step, and the three parent-provided reading activities factors (Letter Activities, Word Activities, and Comprehension Activities) in the second step. As before, child age emerged as a strong predictor of the three constituent and the single overall scores (see Table 9). In addition, Word Activities predicted T1 TERA score, T1 alphabet score, and T1 conventions score. Parents who engaged in Word-level Activities had children who scored higher on the overall T1 TERA test, T1 alphabet subtest, and T1 conventions subtest. Comprehension Activities significantly predicted the T1 meaning subtest score, and the positive relationship between Letter-level Activities and the T1 meaning score approached significance. Children of parents who engaged in Comprehension Activities achieved higher T1 meaning subtest scores.

3.5.3. Time 2 mathematics results

We performed three similar regressions in which we regressed the Time 2 overall TEMA score and the two constituent subscale (formal math subtest and informal math subtest) scores on child age and child gender in the first step, and the three parent-provided mathematics activities factors (T2 Formal Math Activities, T2 Informal Math Activities, and T2 Games, Blocks, and Toys) in the second step. As before, child age accounted for large amounts of variance (see Table 10). T2 Formal Math Activities and T2 Games, Blocks, and Toys positively predicted T2 TEMA Score, T2 informal math score, and T2 formal math score, while T2 Informal Math Activities negatively predicted T2 TEMA score and T2 formal math score. Parents at Time 2 who engaged their children in formal math activities and math-oriented board and card games, blocks, and puzzles had children who scored higher in mathematics. Parents at Time 2, who engaged their child to a greater extent in informal math activities, had children who scored lower in the overall TEMA and the formal math subtest.

3.5.4. Time 2 reading results

We performed four similar regressions, in which we regressed the child's overall Time 2 TERA score and constituent subscale, (alphabet subtest, conventions subtest, and meaning subtest) scores on child age and child gender in the first step, and the two Time 2 reading activities factors (Letter/Word Activities and Comprehension Activities) in the second step (see Table 11). Age again predicted large amounts of variance in the scores. Gender significantly predicted the meaning subtest score, indicating that girls scored somewhat higher than boys. Neither parent-provided reading activity factor predicted TERA scores at Time 2.

3.6. Longitudinal results

3.6.1. Time 1 predictors of Time 2 mathematics outcomes

Following Skwarchuk et al. (2014), we assumed that some effects of early experiences would be measurable a year after parents completed the initial reports of home activities. Controlling for the corresponding Time 1 scores, we performed a series of three stepwise regressions on the Time 2 math outcome variables, regressing the T2 overall TEMA score and the two subscale (informal mathematics and formal mathematics) scores on child age and child gender in the second step and T1 Formal Math Activities, T1 Informal Math Activities, and T1 Fine Motor Activities in the third step (see Table 12). As expected, the Time 1 TEMA score accounted for a large amount of variance (76%) in the Time 2 TEMA score. Child gender and Time 1 Formal Math Activities also predicted significant variance in the T2 overall TEMA score, indicating that boys and children whose parents had engaged them in formal math activities at Time 1 had higher TEMA scores at Time 2. In the second regression, child age, T1 Formal Math Activities, and T1 Fine Motor Activities were all significant positive predictors of the T2 informal math subtest score. This set of results indicated that children who were older and whose parents had reported more frequent experience with formal math activities and fine motor activities at Time 1 scored higher on the T2 informal math subtest. In the third regression, child age and T1 Formal Math Activities were significant predictors of the T2 formal math subtest score. Older children and children who had greater exposure to formal math activities at Time 1 obtained higher formal math subtest scores at Time 2.

3.6.2. Time 1 predictors of Time 2 reading outcomes

Controlling for the corresponding Time 1 scores, we performed a series of four stepwise regressions, regressing the T2 overall TERA score and three constituent subtest (alphabet, conventions, and meaning subtest) scores on child age and child gender in the second step and T1 Letter Activities, T1 Word Activities, and T1Comprehension Activities in the third step (see Table 13). The corresponding Time 1 TERA or subtest score accounted for large amounts of variance (T1 TERA score, 74%; alphabet subtest score, 65%; conventions subtest score, 44%, and meaning subtest score, 28%). Age of child predicted the T2 TERA score, the T2 alphabet subtest score, and the T2 meaning subtest score, indicating that older children received higher scores than did younger children. Gender of child predicted the T2 TERA score and T2 meaning score, indicating that girls obtained somewhat higher scores on the T2 overall TERA and on the T2 meaning subtest. Contrary to our findings for mathematics, only the T1 Letter Activities Factor predicted a T2 reading outcome—the Time 2 TERA score.

3.7. Cross-domain regressions

Our penultimate set of regressions was performed to address the question of whether the parent-provided mathematics activities predicted children's reading scores (see Duncan and Magnuson, 2011) and whether the parent-provided reading activities predicted the children's mathematics scores. In the first set of regressions, we regressed the T1 TERA score on child age, gender, and the three T1 math activities factors (T1 Informal Math Activities, T1 Fine Motor Activities, and T1 Formal Math Activities). This concurrent analysis (see Table 14) revealed that child age and all three math activities factors were significant predictors of the overall T1 TERA score. Regarding TERA subtest scores, all three mathematics activities factors significantly predicted the alphabet subtest score, Fine Motor Activities and Formal Math Activities predicted the conventions subtest score, and Formal Math Activities predicted the meaning subtest score However, in the longitudinal regression, T1 math activities factors did not predict the T2 overall TERA score when we controlled for Time 1 TERA score. Conversely, the reading activities factors did not predict the TEMA score concurrently or longitudinally.

3.8. Comparison of mathematics factors and reading factors as predictors

Our last set of regressions was performed to determine whether mathematics factors or reading factors were better predictors at Time 1. In the first regression, we regressed the Time 1 TEMA score on child age, Letter Activities, Word Activities, Comprehension Activities, Informal Math Activities, Fine Motor Activities, and Formal Math Activities. Results showed that there were three significant predictors of the early mathematics score: Child age ($\beta = .557$, $p < .0001$), Formal Math Activities ($\beta = .307$, $p < .0001$), and Comprehension ($\beta = -.143$, $p < .05$). In the second regression we regressed the Time 1 TERA score on child age, Letter Activities, Word Activities, Comprehension Activities, Informal Math Activities, Fine Motor Activities, and Formal Math Activities. Results showed four significant predictors of the early reading score: Child age ($\beta = .547$, $p < .0001$), Word Activities ($\beta = .227$, $p < .0001$), Informal Math Activities ($\beta = -.171$, $p < .01$), and Formal Math Activities ($\beta = .297$, $p < .0001$). Child age and Formal Mathematics Activities were the only two positive predictors of both the TEMA and TERA at Time 1.

4. Discussion

The parents in the present study situated in the United States seem to play an important role in helping their young children develop mathematics and reading competencies. The home learning activities that parents provided for their children at Time 1, as measured by the EASYC scale, predicted young children's mathematics and reading performance concurrently, and the mathematics scale continued to predict mathematics gain scores a year later. It was notable that the Time 1 Formal Math Activities Factor was a stronger predictor of the Time 1 TEMA score and the Time 1 TERA score than were any of the Time 1 reading activities factors.

4.1. Predictors of mathematics knowledge and skill in young children

With the exception of child age, the T1 Formal Math Activities factor was the most consistent concurrent predictor of the T1 overall TEMA score and the two constituent subtest (formal

Table 10
Concurrent predictors of Time 2 TEMA score and subtest (Informal and Formal) scores.

Child outcome	Predictors	$\sum R^2$	R^2chng	β	ρ
T2 Tema-2 Score		.516			
	Step 1: Age in months		.419	.600	.0001
	Step 2: T2 Formal math activities		.097	.178	.05
	T2 Informal math activities			−.206	.018
	T2 Games and Toys			.230	.008
T2 Informal math score		.480			
	Step 1:Age in months		.401	.608	.0001
	Step 2: T2 Formal math activities		.079	.183	.051
	T2 Informal math activities			−.077	.384
	T2 Games and Toys			.178	.044
T2 Formal math score		.472			
	Step 1: Age in months		.359	.541	.0001
	Step 2: T2 Formal math activities		.113	.165	.080
	T2 Informal math activities			−.280	.002
	T2 Games and toys			.247	.006

Table 11
Concurrent predictors of Time 2 TERA score and subtest scores.

Child outcome	Predictors	$\sum R^2$	R^2chng	β	ρ
T2 TERA-2 Score		.460			
	Step 1: Age in months		.448	.689	.0001
	Step 2: T2 Comprehension activities		.012	.091	.296
	T2 Letter/Word activities			.041	.637
T2 Alphabet score		.345			
	Step 1: Age in months		.334	.597	.0001
	Step 2: T2 Comprehension activities		.011	.083	.393
	T2 Letter/Word activities			.043	.712
T2 Conventions score		.335			
	Step 1: Age in months		.318	.583	.0001
	Step 2: T2 Comprehension activities		.017	.040	.676
	T2 Letter/Word activities			.109	.253
T2 Meaning score		.412			
	Step 1: Age in months		.376	.674	.0001
	Gender		.031	−.173	.046
	Step 2: T2 Comprehension activities		.005	.075	.413
	T2 Letter/Word activities			−.008	.925

Note. Gender is scored 0 = girls and 1 = boys.

Table 12
Longitudinal Predictors of T2 TEMA Score and Subtest (Informal and Formal) Scores.

Child outcome	Predictors	$\sum R^2$	R^2chng	β	ρ
T2 TEMA Score		.800			
	Step 1: Time 1 TEMA score		.756	.741	.0001
	Step 2: Gender		.031	.138	.006
	Age in months			.087	.183
	Step 3: T1 Formal math activities		.013	.130	.015
T2 Informal Score		.706			
	Step 1: T1 Informal subtest score		.627	.595	.0001
	Step 2: Gender		.042	.121	.054
	Age in months			.188	.016
	Step 3: T1 Formal math activities		.023	.135	.044
	T1 Fine motor activities		.014	.122	.045
T2 Formal Score		.679			
	Step 1: T1 Formal subtest score		.618	.596	.0001
	Step 2: Gender		.042	.076	.224
	Age in months			.202	.007
	Step 3: T1 Formal math activities		.019	.152	.022

Note. Gender is scored 0 = girls and 1 = boys.

mathematics and informal mathematics) scores. In the longitudinal regression, T1 Formal Mathematics Activities also predicted the scores of the T2 overall TEMA and both subtests after controlling for the T1 scores. The five activities included were “Add and subtract single-digit numbers,‟Taught him/her to add on fingers,‟Give math challenges while traveling in the car,‟Does math workbooks and worksheets,änd “Uses math software.Öur results support those of Skwarchuk et al. (2014) who found “that advanced (but not basic) formal numeracy practices accounted for individual differences in numeracy outcomes” (p. 80) and those of Huntsinger

Table 13
Longitudinal predictors of T2 TERA score and subtest (Alphabet, Conventions, Meaning) Scores.

Child outcome	Predictors	$\sum R^2$	R^2 chng	β	ρ
T2 TERA Score		.790			
	Step 1: T1 TERA score		.739	.775	.0001
	Step 2: Age in months		.019	.206	.003
	Gender		.016	−.137	.008
	Step 3: Letter activities		.016	.114	.038
	Word Activities			−.079	.168
	Comprehension activities			−.081	.121
T2 Alphabet Score		.598			
	Step 1: T1 Alphabet score		.563	.638	.0001
	Step 2: Age in months		.032	.219	.007
	Step 3: Letter activities		.003	.048	.522
	Word activities			−.026	.742
	Comprehension activities			.027	.705
T2Conventions Score		.447			
	Step 1: T1 Conventions score		.437	. 663	.0001
	Step 2: Letter activities		.010	.084	.340
	Word activities			.027	.772
	Comprehension activities			−.047	.575
T2 Meaning Score		.551			
	Step 1: T1 Meaning score		.280	.409	.0001
	Step 2: Age in months		.211	.527	.0001
	Gender		.043	−.218	.004
	Step 3: Letter activities		.017	.083	.307
	Word activities			.014	.867
	Comprehension activities			−.122	.125

Note. Gender is scored 0 = girls and 1 = boys.

Table 14
Cross-domain predictors of T1 TERA score and subtest (Alphabet, Conventions, Meaning) scores.

Outcome	Predictors	$\sum R^2$	R^2 chng	β	ρ
T1 TERA Score		.534			
	Step 1: Age in months		.419	.572	.0001
	Step 2: Informal math activities		.115	−.121	.042
	Fine motor activities			.134	.018
	Formal math activities			.325	.0001
T1 Alphabet Score		.397			
	Step 1: Age in months		.272	.442	.0001
	Step 2: Informal math activities		.125	−.164	.016
	Fine motor activities			.164	.011
	Formal math activities			.331	.0001
T1Conventions Score		.494			
	Step 1: Age in months		.436	.612	.0001
	Step 2: Informal math activities		.058	−.095	.124
	Fine motor activities			.142	.015
	Formal math activities			.200	.001
T1 Meaning Score		.238			
	Step 1: Age in months		.182	.383	.0001
	Step 2: Informal math activities		.056	.033	.662
	Fine motor activities			−.047	.507
	Formal math activities			.238	.002

Note. Gender was also entered on Step 1, but did not account for any variance at Time 1.

et al. (2000) that showed parent-provided formal math activities predicted math achievement four years later.

At both time points, the Informal Math Activities factor negatively predicted math scores which we believe illustrates the *specificity principle* (Bornstein, 2002). Items common to the Informal Math Activities factor at both time points were “Math-related songs and fingerplays,̈“Reads counting books,änd “Counts objects.P̈arents who reported more frequent use of informal math activities at Time 1 had children who scored lower on the math tests. In contrast, LeFevre et al. (2009) found that informal activities (which included board and card games and measurement and calculation in cooking and carpentry contexts) with kindergartners, first-graders, and second-graders predicted children’s math knowledge and fluency. One reason for the discrepancy between our results and those of Lefevre et al. may be lack of agreement on what constitutes informal and formal experiences. Another possible explanation involves different outcome measures. A third possible reason (and perhaps the most important) involves the ages of the children in the two studies. While the mean age of our participants at Time 1 was 4.99 years of age, the mean age of LeFevre et al.’s participants was 6.79 years. In our study, we found that the Games, Blocks, and Math Toys factor at Time 2 (participants’ mean age = 5.88 years) concurrently predicted performance on the TEMA-2 and the two constituent subtests (informal math score, and formal math score). This Time 2 result is consistent with LeFevre et al. (2009). The T2 Games, Blocks, and Toys factor, which emerged largely from the Time 1 Informal Math Activities factor, consisted of the items “Plays with Tangrams,̈“Plays with blocks or construction toys,̈“Plays with wooden or cardboard puzzles,̈“Plays with math toys,änd “Plays board or card games.C̈onsistent with

Siegler and Ramani (2008, 2009) finding that playing board games improves young children's mathematics performance, the Games, Blocks, and Toys factor positively predicted the overall TEMA score, the informal math score, and the formal math score at Time 2. Skwarchuk et al. (2014) have described these activities as “informal activities,ẅhereas, Huntsinger et al. (1997) have conceptualized them as “semi-formal activities' (activities that are structured by the characteristics of the material – similar to Montessori's or Froebel's materials – or by rules for playing). For example, since the 1920s, early childhood educators in the United States have provided blocks in their classrooms (Balfanz, 1999), motivated by the idea that constructive play with blocks aids a child's understanding of mathematics (Charlesworth, 2005), but there have been few formal studies to substantiate that assertion. Ginsburg, Inoue, and Seo (1999) found that puzzles, continuous objects (e.g., clay), Legos, and blocks are associated with mathematical activity in preschool children. Wolfgang, Stannard, and Jones (2001) have found that block play performance of preschool children predicts later achievement in mathematics. Because we believe that both formal and informal math activities are important (Baroody, Lai, & Mix, 2006), we need to work toward consensus on the definitions of formal and informal activities.

The T1 Fine Motor Activities factor concurrently predicted the overall T1 TEMA-2 score and longitudinally predicted the T2 informal math subtest score. The finding that the parent-provided Fine Motor Activities factor predicted the mathematics test scores supports the discovery by Luo et al. (2010) that fine motor skills of young children are positively associated with their mathematics achievement. However, the T1 fine motor activities “Strings beads in a pattern,̈“Constructs using pattern or symmetry,̈“Practices writing numerals,änd “Folds (Origami) and cuts paper” were not simply motor activities; they also contained elements of mathematics.

4.2. Predictors of reading knowledge and skill

Our EASYC reading scale did predict early reading scores at Time 1. The Word Activities factor, containing the items “Traces or copies words,̈“Asks how to spell words,̈“Practices writing name,änd “I assign words to copy,p̈redicted T1 overall TERA score, T1 alphabet subtest score, and T1 conventions subtest score concurrently. The Comprehension Activities factor (“We play word-rhyming games,̈“Point out words in the environment,̈“Define new words,̈“I ask questions about the story,änd “Listens to stories read by parents or grandparents') significantly predicted the T1 meaning subtest score. Unexpectedly, only T1 Letter-level Activities longitudinally predicted the T2 TERA after controlling for T1 TERA, and none of the reading activities factors predicted reading outcomes concurrently at Time 2. In retrospect, our scale did not include the item, “teaching children to read words,ẅhich has been demonstrated to be consistently correlated with children's early reading (Sénéchal & LeFevre, 2002, 2014). It may also be that our literacy outcome shortchanged another important literacy domain: vocabulary. Had we included a vocabulary assessment as Skwarchuk et al. (2014) and Sénéchal and LeFevre (2014) have done, our reading scale might have shown greater predictive power.

4.3. Individual differences

Analyses did not reveal gender differences in mean group comparisons, but the regressions indicated several small gender differences. Girls scored somewhat higher than boys on the meaning subtest of the TERA at Time 2, and in the longitudinal regression, boys showed greater growth than did girls in the Time 2 TEMA score, when controlling for T1 TEMA score. This set of results conforms to the tendency for girls to do better in reading (Halpern et al., 2007) and boys to do somewhat better in numerical operations (Coley, 2002). There is disagreement, however, on the robustness of meaningful gender differences in mathematics during early childhood, as many studies have found none (e.g., Clements and Sarama, 2008; Lachance & Mazzocco, 2006). We view our findings to be typical of what other researchers have found.

In terms of developmental changes, we noted some changes in the factor makeup from Time 1 to Time 2 in both the mathematics activities scale and the reading activities scale. These changes were expected and are consistent with Sénéchal and LeFevre's findings (2014) who demonstrated that parents change their methods in response to the child's emerging skills.

Several researchers (e.g., LeFevre et al., 2009; Purpura et al., 2011) have noted that it is important to identify the linguistic, quantitative, and spatial attention predictors of all early mathematics skills, including geometry and measurement. Unfortunately our mathematics outcome measure (TEMA-2) did not include items related to geometry or measurement. It remains to be seen whether our Games, Blocks, and Toys factor at Time 2 would be predictive of geometry outcomes. Clements (1999) has long articulated the need to include geometry and spatial thinking in early childhood mathematics programs and assessments. If boys show an early precocious advantage in spatial thinking (e.g., Levine et al., 1999), then special efforts should be made to expose girls to spatial curriculum content and activities in the preschool years.

4.4. Overlap of early reading and mathematics skills in young children

Children's mathematics (TEMA) scores were very highly correlated with children's reading (TERA) scores at both Times 1 and 2. It may be that there is a general academic readiness in the early childhood years (i.e., the “whole child” concept), which does not differentiate into specific academic domains until later in childhood. In the cross-domain regressions we performed linking EASYC factors with literacy and mathematics outcomes, our Formal Mathematics Activities factor accounted for 10% of the variance of the overall TERA-3 (early reading) and predicted the three subtest scores at Time 1, whereas the reading activities factors did not predict the TEMA-2 (early math) score. In contrast, the mathematics activities factors did not continue to predict reading scores at Time 2.

4.5. Limitations and future directions

Several limitations to this study need to be acknowledged. First, the sample was not diverse in that 79% of the participants were European American and most of the children came from middle- and upper middle-income families. The findings may not generalize to children from lower SES families or families with different ethnic backgrounds. Second, we obtained no formal measure of the curricula and teaching quality of the child care centers and kindergartens from which we recruited, although we know that four of the child care centers were NAEYC-accredited and the seven of the eight center directors had master's degrees in ECE (criteria of high quality). Third, our retention rate for the second year was less than 50% of the original participants. Children who were enrolled in the child care center preschools and kindergartens at Time 1 scattered to many different public school kindergartens and first grades at Time 2 located closer to their homes. Unfortunately, we had neither the financial nor the human resources to allow us to travel to so many different schools. We realize that the retained participants may have differed from those whom we failed to retain in some important characteristic. Fourth, this is a correlational study; therefore, we cannot infer cause and effect.

A very recent intervention study, (Berkowitz et al., 2015) has demonstrated that mathematics at home (in the form of an I-Pad app with math story problems) significantly increased children's mathematics achievement in school, especially for children of high math-anxious parents. We need more research on practical interventions which promote parent–child interactions around mathematics. Future work is also needed: (1) to explore which mathematics outcomes have linguistic components (and which literacy outcomes have mathematics components), (2) to partition out the obviously complicated influences of these parent-provided activities on the reading and mathematics outcomes of their young children, and (3) to examine whether and how parents appropriately match activities with children's knowledge and skills.

We set out to develop an activity-based instrument that could be used by researchers to more effectively measure the influence of parental teaching on children's learning. We based our EASYC items on answers parents gave us in response to open-ended questions regarding how they facilitate reading and mathematics development in their children, so we believe that the new measure contains good content validity, but future work will need to verify this contention. With further refinement, the EASYC could be used in conjunction with the EC-HOME or other broad measures of home environment to help capture the early childhood academic socialization environment. Further research should explore the utility of this measure with parents and children from more ethnically and economically diverse contexts, as well as with younger children. This study has identified a number of promising relationships between specific parent practices and children's early mathematics and reading. If future work verifies these associations, it might be appropriate to incorporate this knowledge about successful practices into parenting literature and programs.

5. Conclusion

In summary, the EASYC seems to be a promising instrument for identifying home-based activities which promote mathematics and reading development in young children in the United States. One factor at Time 1, Formal Mathematics Activities, concurrently predicted the overall mathematics score and two subtest scores as well as the overall reading score and three subtest scores, while parent-provided reading activities were not found to influence mathematics scores. The present study may be the first to link specific parent-provided mathematics activities to children's reading development. This research, which has identified home activities that appear to encourage young children's mathematics and reading knowledge and skills, may provide practical information which could be disseminated to parents to aid them in building strong foundations for their young children's academic development.

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Appendix A.

Encouragement of Academic Skills in Young Children (EASYC)

Parents do a lot of different things with their children that may or may not prepare them for school activities and subjects. Below is a list of things that you may or may not do. Please tell us how much you and/or your spouse actually do these things currently.

		Never do it	Sometimes do it	Do it a lot
1	Buy our child workbooks or practice books	1	2	3
2	Limit our child's TV viewing to educational programs	1	2	3
3	Give our child math challenges while traveling in the car	1	2	3
4	Point out letters and words in the environment	1	2	3
5	Teach our child to add small quantities by counting on his or her fingers.	1	2	3
6	Tell our child that it is important to do well in school	1	2	3
7	Assign our child words to copy	1	2	3
8	After reading part of a book, ask questions about the story.	1	2	3
9	Encourage our child to complete workbooks that teach proper letter formation	1	2	3
10	Try to improve our child's vocabulary by defining new words	1	2	3

Have you ever done any of these things?

11	Enroll our child in a Kumon (Japanese) Math program	No	Yes
12	Join a children's book club	No	Yes
13	Have numbers depicted around the house (e.g. placemat, poster, pictures, calendar).	No	Yes
14	Teach my child to tell time	No	Yes

How frequently does your child do each of the following activities at home?

		Never	Occasionally	Often	Very Often
15	15. Play with math-related board and card games.	1	2	3	4
16	Play with math toys, i.e. shape sorters, counting toys	1	2	3	4
17	Play with blocks or construction toys	1	2	3	4
18	Do origami (paper folding) or paper cutting.	1	2	3	4
19	Use pre-reading computer software, i.e., Bailey's Book House	1	2	3	4
20	Do art activities involving pattern or symmetry	1	2	3	4
21	Listen to stories read by parent or grandparent.	1	2	3	4
22	Playing made-up games involving math, i.e. counting steps or counting stuffed animals	1	2	3	4
23	Reading counting or shape books	1	2	3	4

24	Do alphabet workbooks or worksheets	1	2	3	4
25	Sing or listen to songs or fingerplays that use math, i.e. Five Little Monkeys	1	2	3	4
26	. Practice adding and subtracting single digit numbers	1	2	3	4
27	Watching TV shows or videos that teach math	1	2	3	4
28	Play word-rhyming games	1	2	3	4
29	Use math in home routines, e.g., measuring ingredients for cooking	1	2	3	4
30	Do math-related workbooks or worksheets	1	2	3	4
31	Use math software on the computer, i.e. Millie's Math House.	1	2	3	4
32	Attend a story time at a library or bookstore.	1	2	3	4
33	Practice writing his or her name.	1	2	3	4
34	String beads using a repeating pattern	1	2	3	4
35	Draw with crayons or markers	1	2	3	4
36	Our child asks how to spell words	1	2	3	4
37	Trace or copy words on paper.	1	2	3	4
38	Count actual objects or pictures.	1	2	3	4
39	Read books checked out from the library.	1	2	3	4
40	Practice writing numerals 1-10 and beyond	1	2	3	4
41	Play with wooden or cardboard puzzles	1	2	3	4
42	Play with Tangrams (Chinese puzzle).	1	2	3	4

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