Early Education and Development

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/heed20

Preschool Classroom Age Composition and Physical Literacy Environment: Influence on Children's Emergent Literacy Outcomes

Qingqing Yang, Kathryn Zimmermann, Caroline P. Bartholomew, Kelly M. Purtell & Arya Ansari

To cite this article: Qingqing Yang, Kathryn Zimmermann, Caroline P. Bartholomew, Kelly M. Purtell & Arya Ansari (20 Aug 2023): Preschool Classroom Age Composition and Physical Literacy Environment: Influence on Children's Emergent Literacy Outcomes, Early Education and Development, DOI: 10.1080/10409289.2023.2247953

To link to this article: https://doi.org/10.1080/10409289.2023.2247953

Published online: 20 Aug 2023.

EARLY EDUCATION AND DEVELOPMENT
https://doi.org/10.1080/10409289.2023.2247953

Preschool Classroom Age Composition and Physical Literacy Environment: Influence on Children's Emergent Literacy Outcomes

Qingqing Yang[a], Kathryn Zimmermann[a], Caroline P. Bartholomew[b], Kelly M. Purtell[a,c], and Arya Ansari[a,c]

[a]Department of Human Sciences, The Ohio State University; [b]School of Social Work, University of Michigan; [c]Crane Center for Early Childhood Research and Policy, The Ohio State University

ABSTRACT

Research Findings: The classroom physical literacy environment is a malleable and domain-specific contributor to children's emergent literacy acquisition. However, what shapes the physical literacy environment remains unclear. In this study, we drew on a sample of 895 4-year-olds across 223 classrooms from the Professional Development Study and tested the role of classroom age composition in shaping the physical literacy environment. Additionally, we examined the extent to which the physical literacy environment explained the associations between classroom age composition and emergent literacy outcomes. We found that classrooms with a higher proportion of younger children (2- or 3-year-olds) provide less book use, writing materials, and writing around the room. Notably, the lack of writing displayed around the room served as one potential reason why 4-year-olds demonstrate smaller gains in expressive language skills in these classrooms. *Practice or Policy:* Together, these findings highlight the need for investing in the classroom physical literacy environment to ensure that it meets the needs of all children in mixed-age classrooms.

Enrollment in high-quality preschool education improves childhood outcomes such as emergent literacy acquisition, which has implications for long-term school success (Crawford, 1995; Duncan et al., 2007; Pullen & Justice, 2003). Among the many characteristics of a high-quality preschool classroom, one important aspect is the *physical literacy environment*, which is commonly defined by the reading and writing resources available in the classroom and how they are arranged (Altun et al., 2018; Guo et al., 2012). Examples of physical literacy materials include books, writing utensils, language-based puzzles, and alphabet displays. Additionally, certain classroom areas may be designated for reading and writing, while areas utilized for other subjects and activities could incorporate these resources (Smith & Dickinson, 2002). Provision of these materials and areas can promote children's emergent literacy acquisition by allowing them to engage with language- and literacy-related symbols and objects (Guo et al., 2012).

Although research highlights the importance of the physical literacy environment in preschool classrooms (e.g., Arteaga et al., 2019; Baroody & Diamond, 2016), less is known about its predictors. Importantly, recent studies have shown that characteristics of children in the classroom are predictive of the physical literacy environment. For instance, Guo et al. (2013) found that preschool classrooms serving a higher percentage of dual language learners (DLLs) had a lower quality physical literacy environment. Another important characteristic is the age composition of preschoolers, which varies greatly in the United States (Moiduddin et al., 2012). The age composition of classrooms has been

CONTACT Qingqing Yang yang.5180@osu.edu Department of Human Sciences, College of Education & Human Ecology, The Ohio State University, 1787 Neil Ave, Columbus, OH 43210

shown to shape the classroom environment in numerous ways, including classroom quality (Ansari & Pianta, 2019) and children's engagement (Yang et al., 2022). Presumably, children's ages may also shape the ways in which teachers organize their classrooms and provide materials that support emergent literacy acquisition. Therefore, in this study, we examine the extent to which: 1) classroom age composition is associated with the classroom's physical literacy environment, and 2) classroom age composition is associated with children's emergent literacy skill gains through the physical literacy environment. Inquiry into these questions has implications for optimizing classroom environments that can facilitate children's emergent literacy learning in mixed-age classrooms.

Emergent Literacy Skills

Emergent literacy highlights that the development of literacy starts from an early age prior to formal reading and writing instruction, with the term emergent literacy skills referring to a variety of foundational skills that enable skilled and fluent reading and writing (Storch & Whitehurst, 2002; Whitehurst & Lonigan, 1998). The current study focuses on four emergent literacy skills that have been highlighted as the key instructional focus in the preschool period: Receptive and expressive vocabulary and phonological awareness and print knowledge (Lonigan et al., 2011). Although these four skills are moderately to highly correlated (Cabell et al., 2011; Storch & Whitehurst, 2002), they are also strong and independent predictors of reading and writing acquisition (Pullen & Justice, 2003).

Understanding and expressing vocabulary are skills strongly associated with early reading (Dickinson et al., 2019), with prior studies showing that weakness in receptive or expressive vocabulary is associated with early decoding difficulties and later reading difficulties (Lee, 2011; Ouellette, 2006). Phonological awareness, defined as the sensitivity to and ability to manipulate sound structure, has also been found to be a significant predictor of reading skills (Castles & Coltheart, 2004; Kendeou et al., 2009). Finally, children's knowledge of the conventions and forms of written language, namely print knowledge, has been found to predict reading acquisition even after controlling for phonological awareness (Levy et al., 2006; National Early Literacy Panel, 2008).

Preschool Physical Literacy Environment and Children's Emergent Literacy Development

Efforts to enhance children's development through high-quality preschool experiences have primarily focused on social interactions, as emphasized by Bronfenbrenner's bioecological theory (Bronfenbrenner & Morris, 1998). However, research has shown inconsistent associations between preschool classroom social interactional quality and children's emergent literacy skills (Burchinal, 2016; Perlman et al., 2016). Thus, there have been calls for attention to other aspects of classroom experiences highlighted by bioecological theory (Bronfenbrenner & Morris, 1998), such as the objects and symbols available to children that play a unique and predictive role in their development (Wachs, 1990). One such aspect that has received increasing attention is the physical literacy environment (Altun et al., 2018; Guo et al., 2012), which includes the availability, display, and arrangement of literacy materials, such as books, print sources, and writing instruments (Altun et al., 2018; Guo et al., 2012; Wolfersberger et al., 2004). These calls reflect the fact that the literacy environment is not only predictive of children's outcomes, but is more malleable than teachers' social interactions (Markussen-Brown et al., 2017).

When considering the physical literacy environment, there are several theoretical explanations that shed light on how and why the physical literacy environment may shape children's emergent literacy learning. Bioecological theory suggests that the organization, structure, and complexity of the physical environment not only stimulates solitary interactions with objects and symbols, but also provides conditions and stimuli for interpersonal interactions involving literacy-related instruction and modeling (Bronfenbrenner & Morris, 2006). In addition, sociocultural theory emphasizes that children's internalization and use of symbols and signs are first supported by the presence of props and object-orientated play, which involves physical interaction with objects and materials (Vygotsky, 1978).

Taken together, the physical literacy environment can directly elicit literacy-related exploration, manipulation, elaboration, and imagination in children's solitary activities. It can also prompt adult-mediated literacy enriched play where teachers model and scaffold children's use of physical literacy resources (Christie & Enz, 1992; Neuman & Roskos, 1993; Vukelich, 1991).

There are several ways to characterize the classroom physical literacy environment. Classrooms with a rich physical literacy environment have numerous and varied book materials, literacy areas, writing materials, and teacher- and child-directed writing displays and props around the classroom. A high-quality physical literacy environment includes books of varying difficulty levels and genres (e.g., rhyming texts, alphabet books, flap books), related to different curriculum themes, and are arranged in different activity centers (e.g., dramatic play areas, the block center, the science table; Justice, 2006). In addition, high-quality classrooms provide designated areas with writing tools and materials that promote writing and model writing (e.g., newspapers, maps; Guo et al., 2012; Neuman & Roskos, 1990), as well as examples of teacher- and child-directed writing and print products used to guide daily learning experiences (e.g., signs, posters, writing samples; Guo et al., 2012; Phillips et al., 2008).

Classrooms that are rich in literacy materials and areas have been found to increase the frequency, duration, and complexity of literacy-related play (Neuman & Roskos, 1990, 1992). For example, children in intervention classrooms that were enriched with literacy objects in targeted play areas (e.g., the cozy corner library) were observed to spend more time engaging in reading and writing activities, incorporate literacy objects in more diverse and functional ways, and use more explicit language than the nonintervention group (Neuman & Roskos, 1992). In another study, classrooms with high-quality classroom physical literacy environments were strongly associated with children's general literacy interest and engagement in literacy activities. These factors, in turn, predicted their phonological awareness and expressive vocabulary (Baroody & Diamond, 2016). Several studies further demonstrate direct associations between the physical literacy environment and emergent literacy acquisition. For example, Arteaga et al. (2019) found a positive association between engaging with a high-quality physical literacy environment and children's print knowledge. Similarly, other studies have found that the quality of the classroom literacy area is significantly associated with children's alphabet knowledge and name-writing abilities (Guo et al., 2012; Zhang et al., 2015) as well as expressive and receptive vocabulary and phonological awareness (Altun et al., 2018). These findings suggest that there are links between features of the physical literacy environment and children's emergent literacy skills (Altun et al., 2018; Guo et al., 2012; Palmer et al., 2018; Xu et al., 2014).

Despite promising evidence that the physical literacy environment is important for children's early emergent literacy skills, there is limited research on factors that may shape the literacy environment. However, existing research suggests that the physical literacy environment is malleable. For example, interventions aimed at improving teachers' language instruction and implementation of language-focused curricula have shown significant positive changes in the quality of the classroom literacy environment (Arteaga et al., 2019; Palmer et al., 2018). Although promising, more inquiry is needed into what influences the classroom literacy environment and how those factors are related to young children's emergent literacy skills.

Classroom Age Composition, Classroom Environment, and Children's Emergent Literacy Development

The importance and malleability of the physical literacy environment warrant more in-depth studies on what shapes it. Although it is undoubtedly shaped by larger contextual forces (e.g., program funding), understanding more proximal predictors is also important. Mirroring the bidirectional relations between a person and their context proposed by bioecological theory (Bronfenbrenner & Morris, 1998), the physical literacy environment can influence children's emergent literacy learning while simultaneously being shaped by the collective characteristics of children within a classroom. These characteristics may influence teachers' perceptions and beliefs about the developmental needs

and interests of children, which in turn, influences their provision of a high quality physical literacy environment. For example, the classroom language composition (as measured by the percentage of DLLs within the classroom) has been found to be significantly associated with the quality of the physical literacy environment and instruction, such that classrooms serving a larger proportion of DLLs were rated as having a lower quality literacy environment (Guo et al., 2013; Justice et al., 2008).

Another notable feature of classrooms that may shape the literacy environment is the ages of children, commonly referred to as classroom age composition (Moller et al., 2008). Given the less formal regulations around preschool in the United States, mixed-age classrooms, which include children of multiple age groups, are widely used. For example, according to national statistics, over 75% of children in Head Start, the largest publicly funded preschool program in the United States, are enrolled in mixed-age classrooms serving both 3- and 4-year-olds (Moiduddin et al., 2012). National data also reveal that roughly 65% of preschool classrooms, including those in publicly funded programs, have over a 12-month age difference between the oldest and youngest children, with 35% reporting an age difference of 18 months or greater (National Survey of Early Care and Education, 2012). These findings underscore the considerable enrollment of preschoolers in mixed-age classrooms, although the distribution of children in different age groups varies across states and programs (Ansari et al., 2016). Therefore, the current study focuses on the variation in the percentage of children in each age group as indicators of classroom age composition.

Classroom age composition is an important factor to consider because it has been shown to shape children's school performance, including their acquisition of emergent literacy skills (e.g., Ansari et al., 2016; Justice et al., 2019; Moller et al., 2008). A preliminary pattern identified in previous studies suggests that older children in classrooms with a higher proportion of younger peers may gain less in emergent literacy skills, corresponding to 2 to 5 months of academic development (Ansari et al., 2016). However, the mechanisms that link classroom age composition to children's learning are still unclear. Investigating the underlying mechanisms is essential given the prevalence of mixed-age classrooms and the variability in classroom age composition. Moreover, the factors that link classroom age composition and children's learning can inform interventions that seek to optimize children's learning in mixed-age settings.

As part of the current study, we propose that the classroom physical literacy environment may function as a potential mechanism through which classroom age composition shapes children's emergent literacy learning. There is indirect evidence regarding links between classroom age composition and teachers' practices that lends support to this hypothesis. For example, Ansari and Pianta (2019) found that greater classroom age diversity creates challenges for teachers to provide children with high quality emotional and instructional support. As another example, teachers serving classrooms with a larger proportion of younger children have been found to provide less opportunity for children to engage in group and academic instruction (Ansari, 2017). Similarly, classroom age composition may also shape the classroom physical literacy environment due to teachers' beliefs about young children's literacy learning and development, which is discussed below.

Preschool teachers may believe younger children do not need access to the same rich physical literacy environment compared to older children (Lynch, 2009). For example, a study of Head Start teachers revealed that teachers often believed that young children should only engage with literacy materials after mastering social-behavioral skills, such as following directions, abiding by classroom rules, and relating to peers (Powell et al., 2008). Teachers' beliefs about the degree to which children should learn emergent literacy skills at young ages have been found to be positively associated with the amount of teachers' language and literacy-related instructional practices (Schachter et al., 2016). Therefore, teachers with the above-mentioned beliefs may provide fewer literacy-related materials and spaces when teaching in classrooms with a higher percentage of younger children. For example, in a classroom with more 3-year-olds, teachers may provide books with less engaging and complex narratives, and fewer writing materials (e.g., pencils, papers, word cards, templates), and writing displayed around the room (e.g., signs, posters, charts, and children's writing displays). The

lesser provision of literacy-related materials and space in classrooms with more younger children may be especially distinct when it comes to writing-related materials and space. There is evidence showing that although most teachers agreed with research concerning what language and literacy skills children should know in preschool, 30% did not believe that children as young as three years old should learn to write without worrying about spelling knowledge or that these children learn to write by watching teachers write (Hindman & Wasik, 2008).

However, the above-mentioned beliefs are contrary to the emergent literacy-related research and theories which have established that children as young as three years of age are able to develop emergent literacy skills (Puranik & Lonigan, 2011; Whitehurst & Lonigan, 1998). Inadequate access to literacy-stimulating environments in preschool classrooms has been associated with preschoolers' smaller gains in emergent literacy skills (Altun et al., 2018; Guo et al., 2012). Given the potential variation in classroom physical literacy environments based on the ages of children within the classroom and their influence on children's emergent literacy development, we hypothesize that classroom physical literacy environments may mediate the associations between classroom age composition and children's emergent literacy development.

The Current Study

Given the importance and malleability of the classroom physical literacy environment for children's emergent literacy learning, it is critical to investigate the factors that may influence it. Because children's characteristics including age may shape teachers' beliefs and practices about what to provide in the classroom environments (Ansari, 2017; Guo et al., 2013), we focus on classroom age composition as one potential factor that influences the physical literacy environment. Additionally, because the physical literacy environment has been theoretically and empirically suggested as a predictor of children's literacy learning (Altun et al., 2018; Bronfenbrenner & Morris, 2006), we also examine aspects of the physical literacy environment as potential mediators that may explain associations between classroom age composition and children's emergent literacy outcomes (Ansari et al., 2016; Moller et al., 2008). Specifically, we examine: (1) the extent to which classroom age composition is associated with the classroom physical literacy environment; and (2) whether the classroom physical literacy environment accounts for the associations between classroom age composition and children's emergent literacy acquisition. We hypothesize that children may gain less in emergent literacy skills in classrooms with a higher percentage of younger peers as teachers may fail to provide a high-quality and age-appropriate physical literacy environment for them. Our conceptual framework is shown in Figure 1.

Method

Data Source

Data for this study were drawn from the National Center for Research on Early Childhood Education (NCRECE) Professional Development Study (PDS; Hamre et al., 2012; Pianta et al., 2017). The PDS is a longitudinal, randomized controlled trial assessing early childhood education teacher professional development interventions. As part of the PDS, data were collected in three phases with two cohorts of teachers one year apart. In phases 1 and 2, participants were randomly assigned to different intervention groups. Those that participated in phase 2 were eligible to participate in phase 3, which was a year of follow-up used for evaluative data collection from those teachers and newly enrolled children in their classrooms. During all phases, teacher and child demographic information was collected along with observational classroom measures. Child outcomes were only collected in phases 2 and 3.

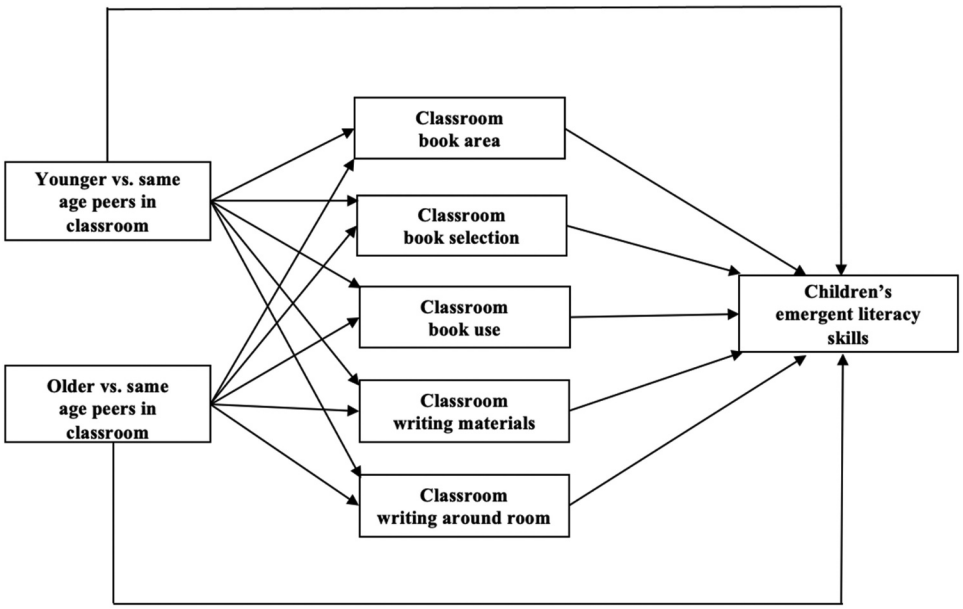

Figure 1. Conceptual framework of the current study.

Participants

In the present study, participants were 895 preschool children (mean age = 4.11 years, *SD* = 0.050) and 223 lead teachers (mean age = 42.56 years, *SD* = 10.55) recruited from multiple Head Start and publicly funded preschool programs across 10 sites in 8 states. Eligibility criteria included classrooms with primarily English instruction, most children proceeding to kindergarten in the subsequent year, and internet access.

Since phase 1 had no child assessments and phase 2 involved an active professional development intervention for teachers (Hamre et al., 2012), we used data regarding class composition, classroom environment, and child outcomes from phase 3 during which no interventions occurred. Teachers participating in phase 3 were diverse in terms of race/ethnicity (47.20% Black/African American, 32.71% White/Caucasian, 11.68% Hispanic/Latine, and 8.41% Other), but not gender (96.26% female). On average, lead teachers reported working at their current schools for 8.42 years.

On average, 4.01 children were selected per classroom to participate in assessments and observations, with the majority of preschool participants being 4-year-olds. Children participating in the phase 3 post-intervention were 49.50% female, 42.20% Black/African American, 13.53% White/Caucasian, 35.21% Hispanic/Latine, and 9.06% Other. More than half of classrooms (54.84%) were Head Start programs, and 35.02% were public pre-kindergartens. Children's families had an average income-to-needs ratio of 1.07, with the average annual household income equaling $23,948 (*SD* = $22,440) and ranging from $2,500 to $87,500. On average, children's mothers completed 12.27 (*SD* = 2.35) years of education with a range from 8.00 and 20.00. Additional descriptive information for participating classrooms, teachers, and children can be found in Table 1.

Measures

Classroom Age Composition

Our focal predictor variable, classroom age composition, was collected through a teacher-report survey administered at the beginning of phase 3. Teachers were asked to disclose the number of 2-, 3-, 4-, and 5-year-old preschool children in their individual classrooms. We utilized these teacher-

Table 1. Descriptive statistics of focal variables and covariates for the sample ($n = 895$).

	Mean(SD)/Percent	Min	Max
Age composition (%)			
2- or 3-year-olds	22.53(24.23)	0	100
4-year-olds	63.06(23.00)	0	100
5-year-olds	14.41(16.15)	0	100
Fall Language			
Receptive language (PPVT)	85.05(19.21)	32	130
Expressive language (WJ)	94.07(19.20)	24	129
Phonological awareness (TOPEL)	90.00(13.88)	54	131
Print knowledge (TOPEL)	95.41(15.11)	73	145
Spring Language			
Receptive language (PPVT)	89.19(17.05)	37	131
Expressive language (WJ)	95.55(15.14)	22	132
Phonological awareness (TOPEL)	92.72(15.16)	55	131
Print knowledge (TOPEL)	102.18(14.98)	66	145
Classroom Physical literacy environment			
ELLCO: Book Area	2.48(0.75)	0	3
ELLCO: Book Selection	6.54(1.25)	3	8
ELLCO: Book Use	4.58(2.61)	0	9
ELLCO: Writing Materials	6.14(1.38)	1	8
ELLCO: Writing Around Room	6.10(2.38)	0	13
Child and family characteristics			
Child age	4.11(0.50)	2.26	5.38
Child gender: female	49.50	-	-
Child race/ethnicity		-	-
Black/African American	42.20	-	-
White/Caucasian	13.53	-	-
Hispanic/Latine	35.21	-	-
Other	9.06	-	-
Household size	4.40(1.64)	2.00	13.00
Number of children under 18	2.40(1.29)	1.00	12.00
Household income/1,000	23.95(22.44)	2.50	87.50
Mothers' education	12.70(2.35)	8.00	20.00
Fathers' lives at home	49.61	-	-
Child primary language is English	84.42	-	-
Teacher characteristics			
Teacher's gender: female	96.26	-	-
Age	42.56(10.55)	22.00	69.00
Teacher race/ethnicity			
Black/African American	47.20	-	-
White/Caucasian	32.71	-	-
Hispanic/Latine	11.68	-	-
Other	8.41	-	-
Years of education	15.81(1.62)	12.00	20.00
Highest degree of education (%)			
Less than associate's degree	7.51	-	-
Associate's degree	28.17	-	-
Bachelor's degree	45.07	-	-
Master's degree or higher	19.25	-	-
Years at current program	8.42(6.39)	1.00	35.00
Years at current position	7.44(5.82)	1.00	33.00
In year 1 intervention	41.89	-	-
Participated in year 1 control	40.54	-	-
Added in year 2, not in year 1	17.57	-	-
In year 2 intervention	50.45	-	-
Participated in year 2 control	49.55	-	-
Classroom characteristics			
Class size	17.31(2.85)	7.00	32.00
Average income-to-needs	1.07(0.77)	0.10	4.34
Racial/ethnic diversity (%)			
White/Caucasian	12.93(22.45)	0.00	95.24
Black/African American	45.69(33.04)	0.00	100.00
Hispanic/Latinx	31.51(28.99)	0.00	100.00
Other	9.86(13.25)	0.00	85.00

(*Continued*)

Table 1. (Continued).

	Mean(SD)/Percent	Min	Max
% of girls in classroom	47.67(12.29)	0.00	85.00
% of children with IEP/IFSP	9.23(11.85)	0.00	63.64
% of children with limited English	15.43(20.52)	0.00	90.00
Child attends Head Start	54.84	-	-
Child attends public school pre-K	35.02	-	-

IEP = Individualized Educational Plan; IFSP = Individualized Family Service Plan.

report data to create variables indicating the percentages of each age group per classroom (see also: Ansari et al., 2016). Due to the limited number of 2-year-olds in our sample, the percentage of 2-year-olds and 3-year-olds were combined as a single "percentage of 2- and 3-year-olds" variable.

Classroom Physical Literacy Environment

To assess the language and literacy related materials and spaces children were exposed to in their classroom environments, we used the literacy environment checklist of the Early Language and Literacy Classroom Observation (ELLCO; Smith & Dickinson, 2002) to create indices of each classroom's physical literacy environment. Following the administration protocols, the literacy environment checklist was completed when the classroom was empty (Smith & Dickinson, 2002). The investigators moved around the classroom, observed the general elements of literacy environment, and completed the checklist in 15–20 minutes.

The literacy environment checklist includes 24 items, which are categorized into five subdimensions: *Book area* (i.e., the arrangement of book area; 3 items; e.g., "Does where the books are located have soft materials?"), *book selection* (i.e., the number, variety, and condition of books; 4 items; e.g., "Do the books in the classroom range in different level?"), *book use* (i.e., the placement and accessibility of books; 5 items; e.g., "How many books are available in the science area?"), *writing materials* (i.e., materials provided to encourage writing; 6 items; e.g., "Is an alphabet visible?"), and *writing around the room* (i.e., the presence of teacher- and child-directed writing displays, writing tools and props around the room, and alphabet/word puzzles; 7 items; e.g., "How many varieties of teacher direction are on display in the classroom?"). Some items were rated using a yes/no response format (e.g., "Is an area set aside just for book reading?") and others were rated in terms of ranges (e.g., How many books are easily available: <15, 16–25, 26>). We used the sum scores of each subdimension. The valid range is 0–3 for book area, 0–8 for book selection, 0–9 for book use, 0–8 for writing materials, and 0–13 for writing around the room.

Children's Emergent Literacy Outcomes

Receptive vocabulary and expressive vocabulary were measured through the Peabody Picture Vocabulary Test 3rd edition (PPVT-III; Dunn & Dunn, 1997) and the Picture Vocabulary subtest of the Woodcock-Johnson III (WJ – III; Woodcock et al., 2001), respectively. Children were assessed twice using both tasks in the fall and spring of the preschool year. During the PPVT-III task, researchers presented children with a series of cards, each of which was printed with four pictures. Researchers then read a word aloud and asked the children to identify the picture that matched the word. During the WJ – III task, researchers asked children to verbally identify objects in the given pictures. Both tasks showed satisfactory reliability ($\alpha = .97$ for the PPVT-III, Dunn & Dunn, 1997; $\alpha = .81$ for the WJ-III; Woodcock et al., 2001). To compare children's performance with the aged norms, we used the standardized scores of the measures.

Phonological awareness and print knowledge were assessed through the two subtests of the Test of Preschool Early Literacy (TOPEL; Lonigan et al., 2007). Phonological awareness measures word elision and blending abilities. For word elision, the child was asked to say a word, then say what is left after dropping out specific sounds for the first 12 items; for blending, the child was asked to listen to

separate sounds and combine them to form a word for the remaining 15 items. Print knowledge measures alphabet knowledge and early knowledge about written language conventions and form. The child was asked to identify letters and written words, point to specific letters, name specific letters, identify letters associated with certain sounds, and verbalize the sounds associated with specific letters. Both subtests demonstrated adequate internal consistency (.78–.89) and concurrent validity (Lonigan et al., 2007). For the purposes of the current study, scaled scores of the TOPEL were used.

Covariates

To reduce the possibility of generating spurious associations due to selection bias, we controlled for child-, teacher-, and classroom-related covariates that have been shown to be associated with children's enrollment into different programs and classrooms as well as their learning outcomes (Aguiar & Aguiar, 2020; Bassok et al., 2018; Crosnoe et al., 2016; Pianta et al., 2005).

For child-level covariates, we controlled for *child characteristics* (age, gender, race/ethnicity), *household resources* (mothers' education, household income, and whether English was the first language spoken at home), *household structure* (household size, number of children under 18 years of age in the home, and whether the father lives at home), and the time between the fall and spring assessments.

For teacher-level covariates, we controlled for teachers' gender, age, race/ethnicity, years of education, highest degree of education obtained, years at the current program, and years at the current position. As teachers were assigned to different intervention conditions in year 1 and year 2 of the larger study, we also controlled for the following three variables. One variable indicated teacher participation in the year 1 intervention or control group. The next variable indicated whether they were added in year 2 (i.e., they did not participate in year 1). The third variable identified if teachers participated in the year 2 intervention or control group.

For classroom-level covariates, we controlled for class size, average classroom income-to-needs ratio, racial/ethnic diversity, percent of girls in the classroom, percent of children with an Individualized Educational Plan (IEP) or an Individualized Family Service Plan (IFSP), percent of children with limited English, whether the classroom was classified as a Head Start, and whether the classroom was classified as a public school.

Analytic Approach

Analyses were performed in Stata IC 16.0 and Mplus 7.0 (Muthén & Muthén, 1998–2015). We used Stata to merge datafiles, calculate descriptive statistics, check for outliers, and assess missing data patterns at the teacher, child, and classroom level. We calculated the skewness and kurtosis of all variables and determined that no outliers needed to be removed (see Table 1). According to our data patterns, we found that on average, participants missed a little under 6% percent of variables. The missingness rate of all variables (i.e., predictors, mediators, outcomes, and covariates) ranged from 0 to 27%, with the pretest phonological awareness assessment showing the highest rate of missingness, along with the covariate capturing time between the pretest and posttest. Little's MCAR test suggested that data were not missing completely at random (χ^2 (4336) = 6219.0120, $p < .001$). Further examination of the missingness pattern indicated that the missingness of outcome variables were associated with child age, race/ethnicity, number of children in the home, living with father or not, teachers' education, percent of Hispanic, percent of children with limited English, whether the classroom was classified as a Head Start, and whether the classroom was classified as a public school. The pattern of missingness indicated a high likelihood of missing at random. We then accounted for missing data by utilizing full information maximum likelihood estimation (FIML). Compared with listwise/pairwise deletion, FIML avoids the loss of statistical power and reduces biased estimation by adjusting the likelihood function to utilize all information from each case (Enders, 2013). Additionally, we addressed the nesting of children within classrooms and potential nonnormality issues by clustering standard errors at the classroom level

Table 2. Unstandardized path coefficients for the association between age composition, classroom language and physical literacy environment, and child outcomes.

	Predictor		
	Younger peers (vs. same age peers)	Older peers (vs. same age peers)	Older peers (vs. younger peers)
Outcome	B(SE)	B(SE)	B(SE)
Classroom physical literacy environment			
Book area	0.03(0.08)	0.12(0.06)	0.10(0.08)
Book selection	−0.12(0.07)	−0.10(0.06)	−0.02(0.06)
Book use	−0.15(0.07)*	−0.01(0.075)	0.10(0.08)
Writing materials	−0.18(0.06)**	0.04(0.05)	0.16(0.05)**
Writing around room	−0.37(0.07)***	−0.06(0.06)	0.20(0.06)**
Children's language and literacy skills			
Receptive vocabulary	−0.01(0.03)	−0.03(0.03)	−0.03(0.03)
Expressive vocabulary	−0.00(0.02)	0.01(0.02)	0.01(0.02)
Phonological awareness	−0.07(0.04)	−0.00(0.04)	0.04(0.04)
Print knowledge	−0.05(0.04)	0.00(0.03)	0.04(0.03)

All continuous variables have been standardized; thus, all estimates can be interpreted as effect sizes Younger peers = 2–3 years old. Same age peers = 4 years old. Older peers = 5 years old.

Analyses controlled for the following child-level covariates: age, gender, race/ethnicity, household size, number of children under 18 years of age in home, household income, mothers' education, father living at home, and English as first language.

Analyses controlled for the following teacher-level covariates: gender, age, race/ethnicity, years of education, highest degree of education obtained, years at current program, years at current position, participation in year 1 intervention group, participation in year 1 control group, added in year 2 (not in year 1), participation in year 2 intervention group, and participation in year 2 control group.

Analyses controlled for the following classroom-level covariates: class size, average classroom income-to-needs ratio, racial/ethnic diversity (%), percent of girls in classroom, percent of children with IEPs/IFSPs, percentage of children with limited English, classified as Head Start, classified as a public school.

*$p < .05$. **$p < .01$. ***$p < .001$.

combined with Maximum Likelihood Robust estimation (MLR; McNeish et al., 2017). Prior to running our models, we standardized all continuous variables (mean = 0, SD = 1) to create coefficients equivalent to effect sizes.

Within this general analytic framework, we performed three series of regression models to address our research questions. In Model 1, we examined our first research question regarding whether variation in the classroom physical literacy environment is explained by the percentage of children in different age groups. We did so by regressing the five dimensions of the classroom physical literacy environment on the classroom age composition indicators and the above-mentioned covariates. To avoid multicollinearity, as the three classroom age composition indicators are proportions and, thus, add up to 1, we estimated this set of models twice, one time using the same age (4-year-old) group as the reference group and the other using the younger age (3-year-old) group as the reference group (see Table 2). In Model 2, we tested whether the five dimensions of the classroom physical literacy environment function as mediators between age composition and children's outcomes using the three steps approach introduced by Preacher and Hayes (2008). First, we tested the direct associations between classroom age composition and our focal outcomes by separately regressing each of the spring emergent literacy outcomes on classroom age composition (controlling for fall scores and covariates). Then, we estimated the associations between the classroom physical literacy environment mediators and children's emergent literacy outcomes in the spring (controlling for fall scores and covariates). Finally, we estimated the indirect effect of classroom age composition on children's emergent literacy gains via the classroom physical literacy environment. To test the significance of each indirect pathway and contextualize the mediating effects, we entered the five physical literacy environment variables together and used the INDIRECT command in Mplus, which tests the significance of each indirect pathway using the Sobel test and estimates the magnitude of mediation by taking the product of coefficients. We tested for the indirect effect even in the absence of significant direct associations between the predictors and outcomes because of the existence of potential suppressors (MacKinnon et al., 2000; Preacher & Hayes, 2008).

Results

Before presenting the results of our research questions, we begin with a discussion of the descriptives of classroom age composition and the physical literacy environment. As shown in Table 1, on average, more than half of the children within these preschool classrooms were 4 years old ($M = 63.06\%$); approximately a quarter were 2-or 3-year-olds ($M = 22.53\%$), and a small proportion were 5-year-olds ($M = 14.41\%$). Sample descriptives also revealed that the age composition varied across classrooms, with each age group showing high standard deviations (range = 16.15–24.23). Additionally, based on the distribution of the current sample, on average, classrooms had an organized book area ($M = 2.48$, $SD = 0.75$ out of a scale of 0–3) and offered a satisfactory number and variety of books (book selection; $M = 6.54$, $SD = 1.25$ out of a scale of 0–8) and writing materials ($M = 6.14$, $SD = 1.38$ out of a scale of 0–8). On the other hand, the placement and accessibility of books in the classrooms (book use; $M = 4.58$, $SD = 2.61$ out of a scale of 0–9) and teacher- and child-directed writing and props on display (writing around the room; $M = 6.10$, $SD = 2.38$ out of a scale of 0–13) were not as sufficient.

To answer research question 1, we tested the associations between classroom age composition and the five dimensions of the classroom physical literacy environment. We found that, on average, classrooms with a greater number of younger (3-year-old) children had less book use ($B = -0.15$, $p < .05$), writing materials ($B = -0.18$, $p < .01$), and writing displayed around the room ($B = -0.37$, $p < .001$) compared with classrooms with a higher proportion of same age (4-year-old) children (see Table 2). Additionally, compared with children in classrooms with a higher proportion of younger children, children in classrooms with more older peers had greater access to writing materials ($B = 0.16$, $p < .01$) and writing around the room ($B = 0.20$, $p < .01$).

In addressing research question 2 regarding the mediating role of the classroom physical literacy environment, we first tested the direct associations between classroom age composition and children's emergent literacy outcomes; none of these direct associations were significant ($|B| = 0.00–0.07$). Having tested these direct effects, we then tested whether classroom age composition was indirectly associated with children's outcomes via the physical literacy environment. A test of the 40 mediating pathways through classroom physical literacy environment only revealed two significant indirect pathways (see Table 3). Specifically, children in classrooms with a higher proportion of younger peers compared to same-age peers were less likely to be exposed to writing around the classroom, which in turn, was associated with less optimal gains in expressive vocabulary ($B_{indirect} = -0.013$, $p < .05$). Conversely, classrooms with more older children compared with younger children had higher gains in expressive vocabulary in part because of more writing displayed around the classroom ($B_{indirect} = 0.02$, $p < .05$).

Discussion

Understanding how the classroom environment shapes emergent literacy skills is critical, as these skills are among the strongest predictors of later reading skills and long-term school success (Crawford, 1995; Duncan et al., 2007; Pullen & Justice, 2003). The current study focused on the classroom physical literacy environment as it represents one critical aspect of classroom structural environment that is not only more feasible to change compared to process quality but also has been shown to be strongly associated with children's emergent literacy development (e.g., Altun et al., 2018; Guo et al., 2012; Palmer et al., 2018). However, relatively little is known about the factors that shape the classroom physical literacy environment. Accordingly, we focused on one aspect of the classroom ecology, age composition, which is often used to regulate program eligibility and varies widely. More specifically, we investigated: (1) whether the age composition of classrooms shaped the classroom physical literacy environment; and (2) the extent to which the physical literacy environment accounted for the associations between classroom age composition and children's acquisition of emergent literacy skills. When taken together, our findings have three take-home messages that we discuss in more detail below.

Table 3. Unstandardized direct/indirect coefficients for classroom language and physical literacy environment as mediators between age composition and child outcomes.

	Outcome			
Predictor	Receptive vocabulary	Expressive vocabulary	Phonological awareness	Print knowledge
Book area as the mediator				
Book area ➔ child outcome	−0.07(0.02)**	0.03(0.02)	0.00(0.04)	0.03(0.03)
Younger vs. same ➔ book area ➔ child outcome	−0.00(0.01)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Older vs. same ➔ book area ➔ child outcome	−0.01(0.01)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Older vs. younger ➔ book area ➔ child outcome	−0.01(0.01)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Book selection as the mediator				
Book selection ➔ child outcome	0.03(0.03)	−0.04(0.03)	−0.05(0.05)	0.00(0.04)
Younger vs. same ➔ book selection ➔ child outcome	−0.00(0.00)	0.00(0.00)	0.01(0.01)	0.00(0.01)
Older vs. same ➔ book selection ➔ child outcome	−0.00(0.00)	0.00(0.00)	0.01(0.01)	0.00(0.00)
Older vs. younger ➔ book selection ➔ child outcome	−0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Book use as the mediator				
Book use ➔ child outcome	−0.04(0.03)	−0.00(0.02)	0.04(0.05)	0.00(0.03)
Younger vs. same ➔ book use ➔ child outcome	0.01(0.01)	0.00(0.00)	−0.01(0.01)	−0.00 (0.01)
Older vs. same ➔ book use ➔ child outcome	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Older vs. younger ➔ book use ➔ child outcome	−0.00(0.00)	0.00(0.00)	0.00(0.01)	0.00(0.00)
Writing materials as the mediator				
Writing materials ➔ child outcome	0.06(0.03)	−0.04(0.04)	−0.03(0.06)	−0.04 (0.04)
Younger vs. same ➔ writing materials ➔ child outcome	−0.01(0.01)	0.01(0.01)	0.01(0.01)	0.01(0.01)
Older vs. same ➔ writing materials ➔ child outcome	0.00(0.00) 0.01(0.01)	−0.00(0.00) −0.01(0.01)	−0.00(0.00) −0.01(0.01)	−0.00 (0.00) −0.01 (0.01)
Older vs. younger ➔ writing materials ➔ child outcome				
Writing around room (WAR) as the mediator				
Writing around room ➔ child outcome	0.03(0.03)	0.08(0.03)**	0.08(0.05)	0.03(0.04)
Younger vs. same ➔ WAR ➔ child outcome	−0.01(0.01)	−0.03(0.13)*	−0.03(0.02)	−0.01 (0.02)
Older vs. same ➔ WAR ➔ child outcome	−0.00(0.00)	−0.01(0.01)	−0.01(0.01)	−0.00 (0.00)
Older vs. younger ➔ WAR ➔ child outcome	0.01(0.01)	0.02(0.01)*	0.02(0.01)	0.01(0.01)

Younger peers = 2–3 years old. Same age peers = 4 years old. Older peers = 5 years old.

Analyses controlled for the following child-level covariates: age, gender, race/ethnicity, household size, number of children under 18 years of age in home, household income, mothers' education, father living at home, and English as first language.

Analyses controlled for the following teacher-level covariates: gender, age, race/ethnicity, years of education, highest degree of education obtained, years at current program, years at current position, participation in year 1 intervention group, participation in year 1 control group, added in year 2 (not in year 1), participation in year 2 intervention group, and participation in year 2 control group.

Analyses controlled for the following classroom-level covariates: class size, average classroom income-to-needs ratio, racial/ethnic diversity (%), percent of girls in classroom, percent of children with IEPs/IFSPs, percentage of children with limited English, classified as Head Start, classified as a public school.

*$p < .05$. **$p < .01$. ***$p < .001$.

First, we found that preschool classrooms with a higher proportion of younger children provide less language and literacy materials and spaces, especially book use, writing materials, and writing around the room. These findings align with prior literature that document negative associations between the proportion of younger children (or within-classroom variability of children's ages) with classroom emotional and instructional support and time spent in group and academic instruction (Ansari, 2017; Ansari & Pianta, 2019). We extended prior work by demonstrating that the age composition of classrooms shapes another important aspect of the classroom context, namely the physical literacy environment. Our findings on the negative associations between the proportion of younger children with writing materials and writing around room may be explained by teachers' beliefs and knowledge of children's reading and writing skill development. That is, teachers may arrange fewer books in other

areas, provide fewer writing materials, and organize less writing activities in classrooms with a higher percentage of 2-or 3-year-olds because they design the physical literacy environment according to their understanding of the "needs" of younger children (Hindman & Wasik, 2008; Powell et al., 2008). However, these beliefs and practices may not be developmentally appropriate as studies have shown that children as young as 3 have the capacity to develop writing knowledge and skills, including organizing writing units/marks in straight lines, using spaces to separate words, and applying accurate directionality while writing (Puranik & Lonigan, 2011). Inadequate book use, writing materials, and evidence of writing activities in classrooms with a higher proportion of younger children are potentially problematic because these aspects of the physical literacy environment have been shown to benefit emergent literacy learning for children across all age groups (Altun et al., 2018; Guo et al., 2012; Palmer et al., 2018). Accordingly, these findings underscore the importance of teacher professional development targeting knowledge about what young children need for developing emergent literacy skills and providing a quality physical literacy environment within mixed-age classrooms.

Next, we found that writing around the room partially accounts for the association between classroom age composition and children's gains in expressive vocabulary. Specifically, children in classrooms with a higher proportion of younger peers compared to same-age or older-age peers demonstrated smaller gains in expressive vocabulary partially due to fewer provision of writing activities. Although some studies have suggested older children may gain less in emergent literacy skills when entering mixed age classrooms with a large proportion of younger peers (e.g., Ansari et al., 2016; Moller et al., 2008), the mechanism underlying this association remains unclear. The current study sought to address this gap in knowledge by examining the role of the classroom physical literacy environment. Our findings suggest that 4-year-olds in classrooms with a greater number of younger classmates may be exposed to fewer writing displays and evidence of writing-related activities in their classrooms, which in turn, is associated with their smaller gains in expressive vocabulary skills. Specifically, seeing more writing (e.g., posters, signs, teacher and child writing samples) around the classroom may create more prompts for children to practice and learn expressive vocabulary because these writings are usually designed to enrich children's learning experiences in either a way related to the classroom theme or to children's daily life. In addition, writing around the room, especially child-directed writing displays, can be viewed as evidence of writing-related activities (Quinn et al., 2022), which also provide children with opportunities to learn different vocabulary (Zhang et al., 2015). Given that the physical literacy environment is highly malleable (Markussen-Brown et al., 2017), providing age-appropriate literacy materials and investing in the physical literacy environment may be a feasible approach to ensure 4-year-olds acquire emergent literacy skills in mixed-age classrooms.

However, we did not find evidence of mediation for the other emergent literacy outcomes, including receptive vocabulary, phonological awareness, and print knowledge. Overall, the associations between the five indicators of physical literacy environment and these outcomes were small in magnitude. These small and nonsignificant associations do not imply that physical literacy environments are not important for children's receptive vocabulary, phonological awareness, and print knowledge learning as previous studies have documented such associations (Altun et al., 2018; Baroody & Diamond, 2016). One potential explanation is that physical literacy environments may shape the learning of these skills only when combined with high quality instruction and scaffolding (Guo et al., 2012). Future studies can investigate how classroom physical literacy environment and teacher-child literacy-related interactions in this environment interactively shape children's emergent literacy learning.

Lastly, our results revealed that other aspects of physical literacy environments (i.e., book area, book selection, book use, and writing materials) did not play a mediating role in the associations between classroom age composition and children's emergent literacy development. The failure to detect a mediating effect is potentially because our measure of physical literacy environments only assessed the presence and quantity of literacy-related areas and materials without capturing children's engagement. Previous literature has shown great variability in children's interaction with the available materials in classrooms (Sawyer et al., 2018; Vitiello et al., 2012), which is the more proximal process

shaping their gains from these environments (Sabol et al., 2018; Vitiello et al., 2012). Therefore, future studies need to continue investigating the mechanism through which classroom age composition is associated with children's skill gains. These relations can be explored by measuring more nuanced aspects of classroom processes, including the frequency and quality of reading and writing activities.

Limitations and Future Directions

The current study contributes to the extant literature by investigating the potential role of the classroom physical literacy environment as a mechanism through which classroom age composition may shape 4-year-olds' emergent literacy learning. However, the results of this investigation need to be interpreted in light of several limitations. First, the sample of this study was drawn from either Head Start or public preschool programs in eight states, which limits the generalizability of our findings in other populations. Our findings are also not applicable to Montessori classrooms, which follow a different type of curriculum and use specifically designed materials (Montessori, 2004). That said, our sample represented an ethnically and geographically diverse population of children with low-income backgrounds, which increases the implications of our findings for publicly funded programs.

Second, we only focused on emergent literacy outcomes of 4-year-olds in these programs due to the design of the larger study. Since 3-year-olds and 5-year-olds may have different developmental needs and interests and respond to the physical literacy environment differently from 4-year-olds (Pezoa et al., 2019), our findings on the mediating role of the physical literacy environment may not apply to these two age groups. However, studies show that low-quality physical literacy environments have negative ramifications on the emergent literacy development of children in all age groups (Altun et al., 2018; Guo et al., 2012; Palmer et al., 2018). Thus, 3-year-olds and 5-year-olds may also underperform due to an insufficient literacy environment in classrooms with a higher proportion of younger children. Given the limited and mixed findings on the learning outcomes of these two age groups in previous studies (Guo et al., 2014; Justice et al., 2019), more work on how the physical literacy environment influences the learning of these children in mixed-age contexts is needed.

Third, the measure of literacy environment in this study mainly captures how teachers set up literacy-related materials and areas, without reflecting how teachers and children interact with these environments. Nevertheless, the ELLCO provides information on multiple aspects of physical literacy environment and has been widely used in relevant studies. Despite our study providing preliminary evidence on the associations between classroom age composition and the literacy environment, more in-depth observations on classroom literacy activities are needed to further elucidate children's emergent literacy learning experiences in mixed-age classrooms. Moreover, the original study did not collect data on the exact ages of all children within each classroom; thus, our measure of age composition generated from teacher-reported numbers of children in each age group may be subject to measurement errors and mask the heterogeneity of children's ages within each age group. Lastly, even though we controlled for an extensive set of covariates, including children's baseline emergent literacy skills, causal inference cannot be generated given the correlational nature of the current study.

Implications and Conclusion

With these limitations and future directions in mind, this study provides much-needed insight into how mixed-age classroom contexts shape children's literacy learning environments and outcomes. Our findings revealed that the physical literacy environment varies by classroom age composition in a way that classrooms with a higher proportion of younger children may provide less book use, writing materials, and writing around the room. More importantly, the lack of writing displayed around the room may function as one potential path through which 4-year-olds gain less expressive language skills in these classrooms. Given the prevalence of mixed-age classrooms and the malleability of physical literacy environments through interventions including professional development (Arteaga et al., 2019; Palmer et al., 2018), these findings underscore

the need for optimizing the physical literacy environment to meet the needs of all children in mixed-age classrooms and more investigation into the nuanced classroom process underlying these findings.

Disclosure Statement

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

References

Aguiar, A. L., & Aguiar, C. (2020). Classroom composition and quality in early childhood education: A systematic review. *Children and Youth Services Review*, *115*, 105086. https://doi.org/10.1016/j.childyouth.2020.105086

Altun, D., Tantekin Erden, F., & Snow, C. E. (2018). A multilevel analysis of home and classroom literacy environments in relation to preschoolers' early literacy development. *Psychology in the Schools*, *55*(9), 1098–1120. https://doi.org/10.1002/pits.22153

Ansari, A. (2017). Multigrade kindergarten classrooms and children's academic achievement, executive function, and socioemotional development. *Infant and Child Development*, *26*(6), e2036. https://doi.org/10.1002/icd.2036

Ansari, A., & Pianta, R. C. (2019). Teacher–child interaction quality as a function of classroom age diversity and teachers' beliefs and qualifications. *Applied Developmental Science*, *23*(3), 294–304. https://doi.org/10.1080/10888691.2018.1439749

Ansari, A., Purtell, K., & Gershoff, E. (2016). Classroom age composition and the school readiness of 3- and 4-year-olds in the Head Start program. *Psychological Science*, *27*(1), 53–63. https://doi.org/10.1177/0956797615610882

Arteaga, I., Thornburg, K., Darolia, R., & Hawks, J. (2019). Improving teacher practices with children under five: Experimental evidence from the Mississippi buildings blocks. *Evaluation Review*, *43*(1–2), 41–76. https://doi.org/10.1177/0193841X19865070

Baroody, A. E., & Diamond, K. E. (2016). Associations among preschool children's classroom literacy environment, interest and engagement in literacy activities, and early reading skills. *Journal of Early Childhood Research*, *14*(2), 146–162. https://doi.org/10.1177/1476718X14529280

Bassok, D., Magouirk, P., Markowitz, A. J., & Player, D. (2018). Are there differences in parents' preferences and search processes across preschool types? Evidence from Louisiana. *Early Childhood Research Quarterly*, *44*, 43–54. https://doi.org/10.1016/j.ecresq.2018.01.006

Bronfenbrenner, U., & Morris, P. A. (1998). The ecology of developmental processes. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology: Theoretical models of human development* (pp. 993–1028). John Wiley & Sons Inc.

Bronfenbrenner, U., & Morris, P. A. (2006). The Bioecological Model of Human Development. In R. M. Lerner & W. Damon (Eds.), *Handbook of child psychology: Theoretical models of human development* (pp. 793–828). John Wiley & Sons, Inc.

Burchinal, M., Xue, Y., Auger, A., Tien, H., Mashburn, A., Cavadel, E. W., & Peisner-Feinberg, E. (2016). II. Quality thresholds, features, and dosage in early care and education: Methods. *Monographs Society Research Child*, *81*(2), 27–45. https://doi.org/10.1111/mono.12237

Cabell, S. Q., Justice, L. M., Konold, T. R., & McGinty, A. S. (2011). Profiles of emergent literacy skills among preschool children who are at risk for academic difficulties. *Early Childhood Research Quarterly*, *26*(1), 1–14. https://doi.org/10.1016/j.ecresq.2010.05.003

Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition*, *91*(1), 77–111. https://doi.org/10.1016/S0010-0277(03)00164-1

Christie, J. F., & Enz, B. (1992). The effects of literacy play interventions on preschoolers' play patterns and literacy development. *Early Education and Development*, *3*(3), 205–220. https://doi.org/10.1207/s15566935eed0303_1

Crawford, P. (1995). Early literacy: Emerging perspectives. *Journal of Research in Childhood Education*, *10*(1), 71–86. https://doi.org/10.1080/02568549509594689

Crosnoe, R., Purtell, K. M., Davis-Kean, P., Ansari, A., & Benner, A. D. (2016). The selection of children from low-income families into preschool. *Developmental Psychology*, *52*(4), 599–612. https://doi.org/10.1037/dev0000101

Dickinson, D. K., Nesbitt, K. T., & Hofer, K. G. (2019). Effects of language on initial reading: Direct and indirect associations between code and language from preschool to first grade. *Early Childhood Research Quarterly*, *49*, 122–137. https://doi.org/10.1016/j.ecresq.2019.04.005

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L. S., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K., & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology*, *43*(6), 1428–1446. https://doi.org/10.1037/0012-1649.43.6.1428

Dunn, L. M., & Dunn, D. M., (Eds.). (1997). Peabody picture vocabulary test, fourth edition (PPVT). In *Encyclopedia of autism spectrum disorders* (pp. 2146–2146). Springer. https://doi.org/10.1007/978-1-4419-1698-3_101008

Enders, C. K. (2013). Dealing with missing data in developmental research. *Child Development Perspectives*, *7*(1), 27–31. https://doi.org/10.1111/cdep.12008

Guo, Y., Justice, L. M., Kaderavek, J. N., & McGinty, A. (2012). The literacy environment of preschool classrooms: Contributions to children's emergent literacy growth: Classroom literacy environment. *Journal of Research in Reading*, *35*(3), 308–327. https://doi.org/10.1111/j.1467-9817.2010.01467.x

Guo, Y., Sawyer, B. E., Justice, L. M., & Kaderavek, J. N. (2013). Quality of the literacy environment in inclusive early childhood special education classrooms. *Journal of Early Intervention*, *35*(1), 40–60. https://doi.org/10.1177/1053815113500343

Guo, Y., Tompkins, V., Justice, L., & Petscher, Y. (2014). Classroom age composition and vocabulary development among at-risk preschoolers. *Early Education and Development*, *25*(7), 1016–1034. https://doi.org/10.1080/10409289.2014.893759

Hamre, B. K., Pianta, R. C., Burchinal, M., Field, S., LoCasale-Crouch, J., Downer, J. T., Howes, C., LaParo, K., & Scott-Little, C. (2012). A course on effective teacher-child interactions: Effects on teacher beliefs, knowledge, and observed practice. *American Educational Research Journal*, *49*(1), 88–123. https://doi.org/10.3102/0002831211434596

Hindman, A. H., & Wasik, B. A. (2008). Head Start teachers' beliefs about language and literacy instruction. *Early Childhood Research Quarterly*, *23*(4), 479–492. https://doi.org/10.1016/j.ecresq.2008.06.002

Justice, L. M. (2006). Evidence-based practice, response to intervention, and the prevention of reading difficulties. *Language, Speech, and Hearing Services in Schools*, *37*(4), 284–297. https://doi.org/10.1044/0161-1461

Justice, L. M., Logan, J. A., Purtell, K., Bleses, D., & Højen, A. (2019). Does mixing age groups in early childhood education settings support children's language development? *Applied Developmental Science*, *23*(3), 214–226. https://doi.org/10.1080/10888691.2017.1386100

Justice, L. M., Mashburn, A. J., Hamre, B. K., & Pianta, R. C. (2008). Quality of language and literacy instruction in preschool classrooms serving at-risk pupils. *Early Childhood Research Quarterly*, *23*(1), 51–68. https://doi.org/10.1016/j.ecresq.2007.09.004

Kendeou, P., van den Broek, P., White, M. J., & Lynch, J. S. (2009). Predicting reading comprehension in early elementary school: The independent contributions of oral language and decoding skills. *Journal of Educational Psychology*, *101*(4), 765. https://doi.org/10.1037/a0015956

Lee, J. (2011). Size matters: Early vocabulary as a predictor of language and literacy competence. *Applied Psycholinguistics*, *32*(1), 69–92. https://doi.org/10.1017/S0142716410000299

Levy, B. A., Gong, Z., Hessels, S., Evans, M. A., & Jared, D. (2006). Understanding print: Early reading development and the contributions of home literacy experiences. *Journal of Experimental Child Psychology*, *93*(1), 63–93. https://doi.org/10.1016/j.jecp.2005.07.003

Lonigan, C. J., Farver, J. M., Phillips, B. M., & Clancy-Menchetti, J. (2011). Promoting the development of preschool children's emergent literacy skills: A randomized evaluation of a literacy-focused curriculum and two professional development models. *Reading and Writing*, *24*(3), 305–337. https://doi.org/10.1007/s11145-009-9214-6

Lonigan, C. J., Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (2007). *TOPEL Test of Preschool Early Literacy*. https://www.proedinc.com/Products/12440/topel-test-of-preschool-early-literacy.aspx

Lynch, J. (2009). Preschool teachers' beliefs about children's print literacy development. *Early Years*, *29*(2), 191–203. https://doi.org/10.1080/09575140802628743

MacKinnon, D. P., Krull, J. L., & Lockwood, C. M. (2000). Equivalence of the mediation, confounding and suppression effect. *Prevention Science*, *1*(4), 173–181. https://doi.org/10.1023/A:1026595011371

Markussen-Brown, J., Juhl, C. B., Piasta, S. B., Bleses, D., Højen, A., & Justice, L. M. (2017). The effects of language- and literacy-focused professional development on early educators and children: A best-evidence meta-analysis. *Early Childhood Research Quarterly*, *38*, 97–115. https://doi.org/10.1016/j.ecresq.2016.07.002

McNeish, D., Stapleton, L. M., & Silverman, R. D. (2017). On the unnecessary ubiquity of hierarchical linear modeling. *Psychological Methods*, *22*(1), 114–140. https://doi.org/10.1037/met0000078

Moiduddin, E., Aikens, N., Tarullo, L. B., West, J., & Xue, Y. (2012). *Child outcomes and classroom quality in FACES 2009*. Office of Planning, Research, and Evaluation, U.S. Department of Health and Human Services.

Moller, A. C., Forbes-Jones, E., & Hightower, A. D. (2008). Classroom age composition and developmental change in 70 urban preschool classrooms. *Journal of Educational Psychology*, *100*(4), 741–753. https://doi.org/10.1037/a0013099

Montessori, M. (2004). *The discovery of the child*. ClioPress.

Muthén, L. K., & Muthén, B. O. (1998-2015). *Mplus user's guide* (7th ed.). Muthén & Muthén.

National Early Literacy Panel. (2008). *Developing early literacy: Report of the national early literacy panel*. National Institute for Literacy. http://www.nifl.gov.proxy.lib.ohio-state.edu/earlychildhood/NELP/NELPreport.htm

National Survey of Early Care and Education. (2012). *Public dataset for center-based provider survey*. Administration for Children and Families.

Neuman, S. B., & Roskos, K. (1990). The influence of literacy-enriched play settings on preschoolers' engagement with written language. *National Reading Conference Yearbook*, *39*, 179–187.

Neuman, S. B., & Roskos, K. (1992). Literacy objects as cultural tools: Effects on children's literacy behaviors in play. *Reading Research Quarterly*, *27*(3), 203–225. https://doi.org/10.2307/747792

Neuman, S. B., & Roskos, K. (1993). Access to print for children of poverty: Differential effects of adult mediation and literacy-enriched play settings on environmental and functional print tasks. *American Educational Research Journal*, *30*(1), 95–122. https://doi.org/10.3102/00028312030001095

Ouellette, G. P. (2006). What's meaning got to do with it: The role of vocabulary in word reading and reading comprehension. *Journal of Educational Psychology*, *98*(3), 554–566. https://doi.org/10.1037/0022-0663.98.3.554

Palmer, S. B., Fleming, K. K., Horn, E. M., Butera, G. D., Lieber, J. A., & Palmer, S. B. (2018). Progress monitoring in inclusive preschools: Using children's school success+ curriculum framework. *Inclusion*, *6*(2), 110–126. https://doi.org/10.1352/2326-6988-6.2.110

Perlman, M., Falenchuk, O., Fletcher, B., McMullen, E., Beyene, J., Shah, P. S., & van Wouwe, J. P. (2016). A systematic review and meta-analysis of a measure of staff/child interaction quality (the classroom assessment scoring system) in early childhood education and care settings and child outcomes. *PLOS ONE*, *11*(12), e0167660. https://doi.org/10.1371/journal.pone.0167660

Pezoa, J. P., Mendive, S., & Strasser, K. (2019). Reading interest and family literacy practices from prekindergarten to kindergarten: Contributions from a cross-lagged analysis. *Early Childhood Research Quarterly*, *47*, 284–295. https://doi.org/10.1016/j.ecresq.2018.12.014

Phillips, B. M., Clancy-Menchetti, J., & Lonigan, C. J. (2008). Successful phonological awareness instruction with preschool children: Lessons from the classroom. *Topics in Early Childhood Special Education*, *28*(1), 3–17. https://doi.org/10.1177/0271121407313813

Pianta, R., Hamre, B., Downer, J., Burchinal, M., Williford, A., LoCasale-Crouch, J., Howes, C., Paro, K. L., & Scott-Little, C. (2017). Early childhood professional development: Coaching and coursework effects on indicators of children's school readiness. *Early Education and Development*, *28*(8), 956–975. https://doi.org/10.1080/10409289.2017.1319783

Pianta, R., Howes, C., Burchinal, M., Bryant, D., Clifford, R., Early, D., & Barbarin, O. (2005). Features of pre-kindergarten programs, classrooms, and teachers: Do they predict observed classroom quality and child-teacher interactions? *Applied Developmental Science*, *9*(3), 144–159. https://doi.org/10.1207/s1532480xads0903_2

Powell, D. R., Diamond, K. E., Bojczyk, K. E., & Gerde, H. K. (2008). Head Start teachers' perspectives on early literacy. *Journal of Literacy Research*, *40*(4), 422–460. https://doi.org/10.1080/10862960802637612

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*(3), 879–891. https://doi.org/10.3758/BRM.40.3.879

Pullen, P. C., & Justice, L. M. (2003). Enhancing phonological awareness, print awareness, and oral language skills in preschool children. *Intervention in School and Clinic*, *39*(2), 87–98. https://doi.org/10.1177/10534512030390020401

Puranik, C. S., & Lonigan, C. J. (2011). From scribbles to scrabble: Preschool children's developing knowledge of written language. *Reading and Writing*, *24*(5), 567–589. https://doi.org/10.1007/s11145-009-9220-8

Quinn, M. F., Gerde, H. K., & Bingham, G. E. (2022). Who, what, and where: Classroom contexts for preschool writing experiences. *Early Education and Development*, *33*(8), 1439–1460. https://doi.org/10.1080/10409289.2021.1979834

Sabol, T. J., Bohlmann, N. L., & Downer, J. T. (2018). Low-income ethnically diverse children's engagement as a predictor of school readiness above preschool classroom quality. *Child Development*, *89*(2), 556–576. https://doi.org/10.1111/cdev.12832

Sawyer, B., Atkins-Burnett, S., Sandilos, L., Hammer, C. S., Lopez, L., & Blair, C. (2018). Variations in classroom language environments of preschool children who are low income and linguistically diverse. *Early Education and Development*, *29*(3), 398–416. https://doi.org/10.1080/10409289.2017.1408373

Schachter, R. E., Spear, C. F., Piasta, S. B., Justice, L. M., & Logan, J. A. R. (2016). Early childhood educators' knowledge, beliefs, education, experiences, and children's language- and literacy-learning opportunities: What is the connection? *Early Childhood Research Quarterly*, *36*, 281–294. https://doi.org/10.1016/j.ecresq.2016.01.008

Smith, M. W., & Dickinson, D. K. (2002). *Early Language and Literacy Classroom Observation (ELLCO) toolkit user's guide*. Brookes.

Storch, S. A., & Whitehurst, G. J. (2002). Oral language and code-related precursors to reading: Evidence from a longitudinal structural model. *Developmental Psychology*, *38*(6), 934–947. https://doi.org/10.1037/0012-1649.38.6.934

Vitiello, V. E., Booren, L. M., Downer, J. T., & Williford, A. (2012). Variation in children's classroom engagement throughout a day in preschool: Relations to classroom and child factors. *Early Childhood Research Quarterly*, *27*(2), 210–220. https://doi.org/10.1016/j.ecresq.2011.08.005

Vukelich, C. (1991). Material and modeling: Promoting literacy during play. In J. F. Christie (Ed.), *Play and early literacy development* (pp. 215–231). State University of New York Press.

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

Wachs, T. D. (1990). Must the physical environment be mediated by the social environment in order to influence development?: A further test. *Journal of Applied Developmental Psychology*, *11*(2), 163–178. https://doi.org/10.1016/0193-3973(90)90003-3

Whitehurst, G. J., & Lonigan, C. J. (1998). Child development and emergent literacy. *Child Development*, *69*(3), 848–872. https://doi.org/10.1111/j.1467-8624.1998.tb06247.x

Wolfersberger, M. E., Reutzel, D. R., Sudweeks, R., & Fawson, P. C. (2004). Developing and validating the Classroom Literacy Environmental Profile (CLEP): A tool for examining the "print richness" of early childhood and elementary classrooms. *Journal of Literacy Research*, *36*(2), 211–272. https://doi.org/10.1207/s15548430jlr3602_4

Woodcock, R. W., McGrew, K., & Mather, N. (2001). *The Woodcock-Johnson tests of cognitive ability* (3rd ed.). Riverside.

Xu, Y., Chin, C., Reed, E., & Hutchinson, C. (2014). The effects of a comprehensive early literacy project on preschoolers' language and literacy skills. *Early Childhood Education Journal*, *42*(5), 295–304. https://doi.org/10.1007/s10643-013-0613-6

Yang, Q., Bartholomew, C. P., Ansari, A., & Purtell, K. M. (2022). Classroom age composition and preschoolers' language and literacy gains: The role of classroom engagement. *Early Childhood Research Quarterly*, *60*, 49–58. https://doi.org/10.1016/j.ecresq.2022.01.001

Zhang, C., Hur, J., Diamond, K. E., & Powell, D. (2015). Classroom writing environments and children's early writing skills: An observational study in Head Start classrooms. *Early Childhood Education Journal*, *43*(4), 307–315. https://doi.org/10.1007/s10643-014-0655-4