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Classroom age composition and preschoolers' language and literacy gains: The role of classroom engagement

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ABSTRACT

Having children of multiple ages in the same preschool classroom is a common practice, and age composition has been shown to shape children's learning. However, there is little understanding of the mechanisms that link age composition to children's development. In this study, we examined the extent to which classroom age composition shaped children's classroom engagement, as well as the mediating role of classroom engagement in the links between classroom age composition and children's language and literacy gains. The data were drawn from the Teacher Professional Development Study, a study of 895 4-year-olds across 223 classrooms. We found that positive engagement with teachers mediated associations between classroom age composition and children's vocabulary gains. Specifically, 4-year-olds in classrooms with a greater number of younger classmates experienced less positive engagement with their teachers, which in turn, contributed to smaller vocabulary gains across the year. In addition, being with a greater number of older classmates was associated with lower negative engagement in the classroom. Results are discussed in relation to exploring the critical role of children's individual-level classroom experiences in mixed-age preschool classrooms.

Classroom age composition and preschoolers' language and literacy gains: the role of classroom engagement

Preschool education plays an important role in facilitating children's language and literacy learning (Bierman et al., 2008; Pinto, Pessanha, & Aguiar, 2013). These early language and literacy skills are critical for children's short- and long-term school success (McLaughlin, Speirs, & Shenassa, 2014; Whitehurst & Lonigan, 1998). However, studies of the structural and process quality of classrooms reveal only small to modest associations with preschoolers' language and literacy growth (Burchinal, 2018). In light of these modest associations, researchers have begun to focus on individual-level experiences that children have in the classroom as potential mechanisms that produce language and literacy gains (Connor et al., 2009; Sabol, Bohlmann, & Downer, 2018). One important aspect of children's individualized classroom experiences is their engagement within the classroom with 3 core developmental resources: Teachers, peers, and tasks (Downer, Booren, Lima, Luckner, & Pianta, 2010).

Despite the importance of classroom engagement for children's overall classroom experience, little is known about what predicts preschoolers' engagement. From a developmental-ecological perspective, one possible driver at the classroom level is the age composition of children in the classroom. Classroom age composition imposes different demands on teachers' provisions of instruction and activities, and shapes with whom children interact in peer play. These factors may influence children's interpersonal dynamics with teachers and peers, as well as their physical interactions with tasks. Therefore, this study incorporates factors across the classroom- and child-level and seeks to examine the extent to which: (a) classroom age composition is associated with 4-year-olds' classroom engagement, and (b) children's classroom engagement mediates associations between classroom age composition and their language and literacy growth. When taken together, the results of this work have the potential to inform classroom configurations and the optimization of children's classroom experiences.

Preschoolers' classroom engagement

Researchers have long been interested in identifying malleable aspects of preschoolers' classroom environment that matter for

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their early learning and development (Paro, M., Pianta, & Stuhlman, 2004, 2012; Sabol, Hong, S., Pianta, & Burchinal, 2013). To date, however, much of the focus has been on the overall structural and process quality of classrooms (e.g., CLASS and ECERS; Early, Sideris, Neitzel, LaForett & Nehler, 2018; Pianta, La Paro & Hamre, 2008), which tend to show only weak to moderate associations with children's skills gains (Burchinal, 2018). These patterns of weak to moderate associations are perhaps not surprising because individual children experience the classroom differently. Put another way, the degree to which children benefit from high quality classrooms is, at least in part, driven by how they engage with the classroom setting (Howes, 2000). In support of these assertions, an emerging body of research suggests that children's individual experiences, including the amount and type of teacher instruction and interactions with teachers, vary greatly among children in the same classroom (Connor et al., 2009; Pelatti, Piasta, Justice, & O'Connell, 2014; Sawyer et al., 2018). For example, Connor et al. (2009) found that the amount of small-group literacy instruction observed for individual children in a first-grade classroom within a 2-hour block ranged from 23 minutes to 43 minutes. The amount of variance in children's individual classroom experience may be especially large in preschool given that preschoolers spend a significant amount of time in free play (Justice, Jiang, Purtell, Lin, & Ansari, 2021). For example, Vitiello, Booren, Downer and Williford (2012) found that 7%–23% of the variance in preschoolers' classroom experiences was attributable to differences between children, which was comparable to the variance at the classroom level (i.e., 3%–22%). As such, the present study moves beyond the 'average' classroom experience and focuses on children's individualized experience of classroom process quality—their engagement in the classroom.

According to Piaget (1983) and Vygotsky (1978), children's development is embedded in their social interactions with their teacher and peers in conjunction with their physical interactions with objects, which are the main resources and mechanisms through which children achieve higher-level skills. Importantly, the ways in which children engage with their teachers, peers, and tasks can be either both positive or negative (McEvoy, Estrem, Rodriguez, & Olson, 2003). As such, prior studies have conceptualized children's classroom engagement as 4 distinct constructs (Bohlmann & Downer, 2016; Sabol et al., 2018). The first dimension, positive engagement with teachers, captures children's emotional connection and communication with their teacher, such as the degree to which children seek proximity to their teachers. The second dimension, positive engagement with peers, refers to children's initiation and maintenance of positive interactions with classmates, including their successful initiation of conversation and play. The third dimension, positive engagement with tasks, taps into the degree to which children orient themselves toward classroom activities, such as remaining focused on an activity for an extended period. Finally, the fourth and final dimension, negative classroom engagement, includes children's conflict with teachers and peers and their display of off-task and dysregulated behaviors (Downer et al., 2010). Taken together, these 4 aspects of engagement collectively reflect the ways in which children engage with, and experience, the classroom setting.

Underscoring the importance of children's classroom engagement, previous studies have shown that both children's positive and negative engagement with teachers, peers, and tasks are each uniquely predictive of their early school success, including their language and literacy development (Bohlmann & Downer, 2016; Sabol et al., 2018; Vitiello & Williford, 2016). Importantly, these associations are over and above the effects of global classroom quality, with a 1 unit change in children's classroom engagement equal to |0.02 - 0.15| unit growth in their language skills and |0.02 - 0.38| unit growth in literacy skills (Sabol et al., 2018). Taken together, the 4 domains of classroom engagement shape children's language and literacy learning through distinct, albeit overlapping ways. For example, children who engage more positively with their teachers and peers have been found to have more positive relationships and experience more dyadic conversations, richer language use, and more individualized learning than children who engage with their teacher and peers less positively (Hartz, Williford, & Koomen, 2017; Justice, McGinty, Zucker, Cabell, & Piasta, 2013). These outcomes are key for children's language and literacy learning (Cabell, Justice, McGinty, DeCoster, & Forston, 2015; Sabol et al., 2018). As another example, children's sustained engagement with tasks and self-regulated learning, facilitate their efficiency of internalizing language and literacy knowledge (Bohlmann & Downer, 2016; Vitiello & Williford, 2016). In contrast, children's negative engagement with teachers, peers, and tasks has been found to result in fewer opportunities for children to participate in activities that involve explicit or implicit language and literacy learning (Sabol et al., 2018; Williford, Maier, Downer, Pianta, & Howes, 2013). The above-reviewed information suggests that children's classroom engagement is a multi-dimensional concept that reflects essential aspects of children's individual classroom experiences and plays a critical role in their later language and literacy development.

Classroom age composition and individual classroom engagement

Despite the important role of children's classroom engagement for their language and literacy development (Bohlmann & Downer, 2016; Sabol et al., 2018; Vitiello & Williford, 2016), we know relatively little about what predicts classroom engagement (Vitiello & Williford, 2020; Vitiello et al., 2012). In this study, we examine the role of classroom age composition and operationalize it as the proportion of children in different age groups at the classroom level. We focus on this aspect of the classroom setting as a predictor of children's engagement for 2 reasons. First, unlike K-12, preschool classrooms often serve children of multiple age groups. According to the national statistics, 47 states allow preschool programs to have mixed-age groupings, and roughly 75% of Head Start classrooms are mixed-age (Moiduddin, Aikens, Tarullo, West, & Xue, 2012; National Center on Child Care Quality Improvement & National Association for Regulatory Administration, 2015). These states provide varied requirements about the expected number of children in each age group and teacher-child ratios, which may contribute to heterogeneity in the distribution of children in different age groups documented in prior work (Ansari, Purtell, & Gershoff, 2016). Second, recent work has shown that the mixture of ages within preschool classrooms has implications for both teachers' classroom practices and children's early learning (Ansari et al., 2016; Bell, Greenfield, & Bulotsky-Shearer, 2013; Moller, Forbes-Jones & Hightower, 2008; Purtell & Ansari, 2018; Yeomans-Maldonado, Justice, & Logan, 2019). For example, 4-year-olds who were enrolled in classrooms with more 3-year-olds demonstrated smaller gains in academic skills (Ansari et al., 2016). Notwithstanding the widespread use of mixed-age classrooms and its connection with children's early learning, we know little about what is needed to ensure that mixed-age classrooms successfully meet the needs of all children. Thus, this study aimed to fill this knowledge gap by examining children's classroom engagement as a potential mechanism. Below, we highlight evidence that suggests age composition may play a role in all 4 types of classroom engagement.

First, the variation in children's needs resulting from mixed-age classrooms may alter the quality of teachers' instructional practices and teacher-child interactions, which directly predicts children's engagement with their teacher (Vitiello & Williford, 2020). For example, teachers in mixed-age classrooms are more likely to ex-

perience challenges in providing age-appropriate literacy stimulation and didactic instruction (Ansari, 2017). These challenges experienced by teachers may, in part, be due to younger children having relatively lower skills on average, which results in the exposure to less effective instruction for older children in the same classroom (Wilkinson & Fung, 2002; Yeomans-Maldonado et al., 2019). In particular, this may reduce exposure to richness and variability in vocabulary and syntactic structure (Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002). Furthermore, studies examining interactional quality conclude that teachers who teach younger children or teach in more age-diverse settings display lower-quality interactions (Ansari & Pianta, 2019; Kuger, Klucziniok, Kaplan, & Rossbach, 2016) but engage in more positive interactions with older and better-behaved children (Vitiello et al., 2012). Therefore, we hypothesize that children in classrooms with more older peers would have more positive engagement with teachers compared with children in classrooms with more younger peers.

Classroom age composition may also explain variation in children's engagement with peers. Developmental studies have long shown that the level of children's language and literacy abilities, as well as social-emotional skills, largely depend on children's age (Skibbe, Montroy, Bowles, & Morrison, 2019). As such, children enrolled in classrooms with a higher percentage of older children are more likely to have interactions with peers who have higher levels of language skills and greater peer language resources (Henry & Rickman, 2007), which in turn, contributes to more positive engagement with peers. In addition, being with older peers may provide younger children with more opportunities to learn and understand others' thoughts and use socially desirable strategies to approach peers (Bandura, 1986; Park & Lee, 2015). With that said, however, previous studies have suggested that a lack of same-aged classmates for the oldest children in a classroom was associated with fewer positive peer interactions (Slot & Bleses, 2018). Thus, it is likely that more positive engagement with peers will occur in classrooms with more older peers than younger peers.

Classroom age composition may also influence children's engagement with tasks. As illustrated earlier, the average age and skills of children in the classroom may shape teachers' provision of tasks and instructional support (Yeomans-Maldonado et al., 2019), which may further influence how well children maintain focus and engage in self-directed learning (Strati, Schmidt, & Maier, 2017). Both the provision of developmentally age-appropriate tasks and quality instructional support in the classroom are likely to foster children's engagement with classroom tasks. However, a larger range of ages in the classroom poses challenges for teachers to provide individualized tasks and instructional support (Ansari, 2017). For example, a recent study by Bartholomew, Yang, Purtell, and Ansari (2021) showed that teachers in mixed-age classrooms serving a larger number of younger children provided fewer writing materials and books on average. In addition, the above-mentioned interpersonal dynamics with teachers and peers resulting from classroom age composition may also ensure emotional security that allows children to better engage in tasks (Alamos & Williford, 2020). Hence, we postulate that children in classrooms with more older peers may display more positive engagement with tasks as compared with children in classrooms with more younger peers.

Lastly, age composition may also influence children's early learning through children's negative classroom engagement. As mentioned above, classroom age composition overlaps with the average levels of language and self-regulation skills as well as skill diversity in the classroom, which can shape the amount of conflict children have with teachers and peers and the degree of behavioral dysregulation during activities. On the one hand, children at different ages display various emotional regulation and social skills (Skibbe et al., 2019), which are associated with the amount of conflict and disruption in the classroom (Cohen & Mendez, 2009). Earlier studies comparing the incidence of peer conflict among different age groups indicate less frequent peer conflict and more child-generated resolution occurring among older age groups (Chen, Fein, Killen, & Tam, 2001; Raikes, Virmani, Thompson & Hatton, 2013). On the other hand, dealing with multiple age groups creates challenges for teachers that are trying to be sensitive and responsive to individual needs (Ansari & Pianta, 2019; Purtell & Ansari, 2018). Indeed, studies have shown that low quality emotional and instructional support may lead children to display more off-task behaviors due to the lack of emotional security they experience (Alamos & Williford, 2020). The lack of responsivity from teachers may even lead children to display disruptive behaviors to draw their teacher's attention (Curby, Downer, & Booren, 2014). Accordingly, in the present study, we expect that being in a classroom with more older peers is associated with less negative engagement than being in a classroom with a higher proportion of younger peers.

The current study

The extant literature reviewed above suggests that being around older classmates may facilitate positive classroom engagement and reduce negative engagement, which may then translate into larger gains in language and literacy skills for children. Studies have documented that classroom age composition, as measured by the proportion of younger classmates or variability/range of children's age in the classroom, are associated with children's language and literacy development (Ansari et al., 2016; Justice, Logan, Purtell, Bleses, & Højen, 2019; Moller et al., 2008). For example, Ansari et al. (2016) found that 4-year-old preschoolers display smaller gains in language and literacy skills in classrooms with a larger proportion of 3-year-olds, and these negative associations are equal to roughly 2 to 5 months of academic development. Despite these documented associations, the mechanisms through which classroom age composition contribute to children's language and literacy gains are not yet well-understood. Given the possible influence of classroom age composition on children's classroom engagement and classroom engagement on language and literacy learning, we test the mediating role of classroom engagement in the association between classroom age composition and preschoolers' language and literacy gains. Due to data limitations and the fact that classroom age composition may matter differentially for children at different age groups (Ansari et al., 2016; Moller et al., 2008), we focus on the experiences of 4-year-olds in mixed-age classrooms to unpack the mechanisms that link classroom age composition with children's language and literacy development. More specifically, this study addresses the following research questions:

1) To what extent does classroom age composition influence 4-year-olds' engagement with teachers, peers, and tasks within the classroom?
2) Do different aspects of classroom engagement mediate the links between classroom age composition and 4-year-olds' gains in language and literacy skills throughout the preschool year?

Method

Participants and procedures

Participants for this study were drawn from the Teacher Professional Development Study conducted by the National Center for Research on Early Childhood Education (Hamre et al., 2012; Pianta et al., 2017), which included 496 teachers from ten sites in 8 different states. As part of the larger study, program administrators and teachers from large community preschools and Head

Start programs across these 8 states were invited to learn about the study details through recruitment meetings. Consenting teachers first participated in a 2-year study with different intervention conditions assigned for each year, and then teachers who participated in year 2 of the study were followed for one additional year of post-intervention data collection. Year 3 only involved data collection for these teachers and newly enrolled children in their classrooms in the fall and/or spring without any additional treatment exposure. To be eligible for inclusion in the larger study, classrooms had to meet the following criteria: Classroom instruction occurred in English for the majority of the time; classrooms were housed in a publicly-funded program, and the classroom did not primarily serve children with disabilities. Then, in each classroom, a specific protocol was followed to recruit 4 children, with preference of assessment and observation given to 4-year-olds.

For the purpose of the present study, we only used year 3 postintervention data. We used data from this year because it included a larger number of observations of children's classroom engagement (4.01 children per classroom) than year 2 (1.86 children per classroom); year 1 had no child observation and assessment data. The total sample from year 3 of data collection included 895 children (443 girls, 452 boys; mean age = 4.11 years, $SD = 0.50$) across 223 classrooms. The participating children were racially and ethnically diverse (Black/African American, 42.20%; Hispanic/Latinx, 35.21%; White, 13.53%; other, 9.06%) and predominantly came from families of low-income. Annual household income averaged $23,948 ($SD$ = $22,440), and maternal education averaged 12.70 ($SD = 2.35$) years. Approximately 55% of children attended Head Start, and 35% attended public preschool (not mutually exclusive). Among the sampled classrooms, almost 70% of teachers had at least a bachelor's degree and had an average of 8.42 years of teaching experience. For more detailed descriptive information regarding the study sample, see Table 1.

Measures

Descriptive information for all focal variables discussed below can be found in Table 2.

Classroom age composition

At the beginning of the school year, teachers reported the number of 2-, 3-, 4-, and 5-year-olds in their classrooms. Note that teachers did not report the exact age of focal children's classmates within their classroom. For the purposes of the present study, we used the estimated percentage of 2-year-olds ($M = 0.24$, $SD = 1.78$), 3-year-olds ($M = 22.29$, $SD = 23.75$), 4-year-olds ($M = 63.06$, $SD = 23.00$), and 5-year-olds ($M = 14.41$, $SD = 16.15$) as our focal variables. Because there were few 2-year-olds across classrooms, we combined the percentage of 2- and 3-years-olds into 1 category ($M = 22.53$, $SD = 24.23$).

Classroom engagement

Children's classroom engagement was assessed during the middle of the 2010 school year using the Individualized Classroom Assessment Scoring System (inCLASS; Downer et al., 2010). The inCLASS was designed to capture the quality of individual children's engagement with teachers, peers, and tasks and was composed of ten dimensions: (a) positive engagement with teachers, (b) communication with teachers, (c) conflict with teachers, (d) sociability with peers, (e) assertiveness with peers, (f) communication with peers, (g) conflict with peers, (h) engagement with tasks, (i) self-reliance with tasks, and (j) behavior control (added as part of a revision to the inCLASS based on the initial validation study). Guided by detailed behavioral markers that indicate low, medium, and high quality, observers rated children's behavior on each dimension on a 7-point scale, with 6–7 indicating high quality, 3–5 indi-

Table 1
Demographic Information for the Sample (n = 895).

	Mean (SD)/Percent
Child and family characteristics	
Child age	4.11 (0.50)
Child gender: female	49.50
Child race/ethnicity	
Black/African American	42.20
White/Caucasian	13.53
Native American/Indian	0.11
Hispanic/Latinx	35.21
Asian/Asian American	4.13
Multiple	4.47
Other	0.34
Household size	4.40 (1.64)
Number of children under 18 years old	2.40 (1.29)
Household income/1000	23.95 (22.44)
Mothers' education	12.70 (2.35)
Fathers' lives at home	49.61
Child language is English	84.42
Teacher characteristics	
Teacher's gender: female	96.26
Age	42.56 (10.55)
Teacher race/ethnicity	
Black/African American	47.20
White/Caucasian	32.71
Hispanic/Latinx	11.68
Asian/Asian American	3.74
Multiple	4.67
Years of education	15.91 (1.62)
Years at current program	8.42 (6.39)
Years at current position	7.44 (5.82)
Participated in year 1 intervention	41.89
Participated in year 1 control	40.54
Added in year 2, not in year 1	17.57
Participated in year 2 intervention	50.45
Participated in year 2 control	49.55
Classroom characteristics	
Class size	17.31(2.85)
Average classroom income-to-needs	1.07(0.77)
Racial/ethnic composition	
% White/Caucasian	12.93 (22.45)
% Black/African American	45.69 (33.04)
% Hispanic/Latinx	31.51 (28.99)
% Pacific islander	0.10 (0.73)
% Asian/Asian American	3.65 (9.86)
% Native American/Indian	0.32 (2.47)
% Multiple	5.08 (7.99)
% Other	0.71 (3.65)
% of girls in classroom	47.67 (12.29)
% of children with IEP/IFSP	9.23 (11.85)
% of children with limited English	15.43 (20.52)
Child attends Head Start	54.84
Child attends public school pre-K	35.02

Table 2
Descriptive statistics of focal variables (n = 895).

	Mean (SD)	Min	Max
Age composition (%)			
2- or 3-yr-olds	22.53 (24.23)	0	100
4-yr-olds	63.06 (23.00)	0	100
5-yr-olds	14.41 (16.15)	0	100
Beginning-of-year 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
End-of-year 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 engagement			
Positive engagement with teacher	2.21 (0.84)	1	6.17
Positive engagement with peers	2.50 (0.88)	1	6.56
Positive engagement with tasks	4.26 (0.81)	1.83	6.50
Negative engagement	1.37 (0.38)	1.00	3.67

cating moderate quality, and 1–2 indicating low quality. The only 2 exceptions were conflict with teachers and peers, where higher ratings indicated more negative engagement.

The initial psychometric study of the inCLASS extracted 4 factors from the above dimensions: positive engagement with teachers (positive emotional connection, interaction and communication with teachers), positive engagement with peers (sociability, assertiveness, and communication with peers), positive engagement with tasks (engagement and self-reliance with tasks), and negative classroom engagement (conflict with teachers and peers; Downer et al., 2010). With the added behavior control (reverse scored) dimension loading onto the negative classroom engagement factor, this 4-factor model has been further validated within racially, linguistically, and socioeconomically diverse samples (Bohlmann et al., 2019; Downer et al., 2010; Slot & Bleses, 2018).

These 4 factors all demonstrated satisfactory internal consistencies in the study sample ($\alpha = 0.99$ across individual factors and the overall scale). The correlations between these 4 factors were small to modest, with the absolute values ranging from 0.04 (positive engagement with peers and negative engagement) to 0.52 (positive engagement with peers and positive engagement with tasks). Two trained raters independently observed the same children for four 15-minute cycles on a single day. The inter-rater reliability during live observations on these scales ranged from 0.71 to 0.99 in a field study; the intra-class correlations (ICCs) across all dimensions reached 0.84, demonstrating good reliability (Downer et al., 2010). Children's engagement scores used in the following analyses are the averages across the 2 raters.

Language and literacy skills

Children's language and literacy skills were assessed with a series of validated measures. First, the Peabody Picture Vocabulary Test 3rd edition (PPVT-III; Dunn & Dunn, 1997) and the Picture Vocabulary subtest of the Woodcock-Johnson III Psychoeducational Battery (WJ–III; Woodcock et al., 2001) were used to assess 2 aspects of language skills: receptive vocabulary and expressive vocabulary, respectively. As part of the PPVT-III, children were presented with a series of cards, with 4 pictures on each one, and then were required to point to a picture in accordance with an orally spoken word. As for the WJ–III, children were asked to name the objects depicted in the given pictures. Both assessments demonstrated satisfactory reliability ($\alpha = 0.97$ for the PPVT-III, Dunn & Dunn, 1997; $\alpha = 0.81$ for the WJ-III, Woodcock et al., 2001). Next, the Test of Preschool Early Literacy (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007) assessed children's phonological awareness and print knowledge. The former focused on children's word elision and blending skills, whereas the latter measured children's knowledge of the alphabet, written language conventions, and writing form. These 2 subtests of the TOPEL showed adequate internal consistency (0.78–0.89) and concurrent validity (Lonigan et al., 2007). For the purposes of the present study, the standardized scores of the PPVT-III and the WJ–III and scaled scores of the TOPEL were used, which allows for children's performance to be compared with their same-aged peers in the population.

Covariates

To reduce the possibility of spurious relations, this study accounted for a rich set of covariates that are shown to be associated with children's enrollment in different types of programs and classrooms as well as children's learning outcomes (Aguiar & Aguiar, 2020; Bassok, Magouirk, Markowitz, & Player, 2018; Crosnoe, Purtell, Davis-Kean, Ansari, & Benner, 2016; Eslava, Deaño, Alfonso, Conde, & García-Señorán, 2016; Pianta et al., 2005). At the child-level, we controlled for child characteristics (child age, gender, race/ethnicity), household recourses (maternal education, household income, home spoken language) and household structure (household size, whether the father lives at home, and the number of children under 18 years old at home). At the classroom-level, we controlled for teacher characteristics (teacher gender, age, race/ethnicity, years of education, years at their current program), other classroom composition indicators (class size, average classroom income-to-needs ratio, classroom racial/ethnic percentage, percentage of girls, percentage of children with an Individualized Educational Plan [IEP] or an Individualized Family Service Plan [IFSP], percentage of children with limited English in the classroom), and the program type (whether the classroom is part of a Head Start program and whether the classroom is located in a public school). In addition, all models adjusted for the time duration between the pre-and post-test (a continuous variable created by subtracting the date of post-test from the date of pre-test), an indicator variable denoting whether the teacher was in the year 1 intervention, an indicator variable denoting whether the teacher was in the year 2 intervention, and a variable indicating whether they joined the study in year 2. We also included indicator variables for each of the classroom sites.

Analytic approach

All analyses were performed in Mplus 7.4 (Muthén & Muthén, 1998). In total, 41% of the sample had complete data on all study variables. The missingness of all variables (i.e., predictors, mediators, outcomes, and covariates) ranged from 11% to 27%, with the pre-test phonological awareness assessment showing the highest rate of missingness, along with the covariate capturing time between the pre-test and post-test. Little's MCAR test suggested that data were not missing completely at random (χ^2 (5263) = 6636.1080, $P < 0.001$). Further examination of the missingness patterns showed that the highest missingness rate was 6% of cases who were missing data on all pre-test scores. The missingness of children's post-test scores were associated with household income, child's race/ethnicity, teachers' age, years of education, race/ethnicity, and classroom site. The pattern of missingness indicated a high possibility of MAR. Given the large number of incomplete cases and the possibility of MAR, we applied full-information maximum likelihood estimation (FIML) to address missing data. FIML uses all available data from each case to estimate the observed variables by adjusting the likelihood function. Thus, this approach produces less biased parameter estimates and avoids the reduction in power of analysis, which makes it more advantageous than listwise/pairwise deletion (Enders, 2013). Additionally, we used clustered standard errors at the classroom level with Maximum Likelihood Robust (MLR) to account for children nested within the classroom and potential nonnormality issues (McNeish, Stapleton, & Silverman, 2017).

Within this general framework, we estimated 3 sets of models to answer our research questions. First, to answer our first research question regarding the associations between classroom age composition and children's classroom engagement, we regressed the 4 factors of classroom engagement on the focal predictors (i.e., classroom age composition). To answer our second question regarding the mediating role of classroom engagement in the link between classroom age composition and children's language and literacy outcomes, we began by testing the direct associations between classroom age composition and our focal outcomes. We tested these associations by regressing each of the language and literacy outcomes on classroom age composition separately (controlling for fall scores). Then, we estimated a set of models with the 4 classroom engagement factors being included as mediators to estimate (a) the associations between the classroom engagement mediators and children's language and literacy skill gains across

the pre-K year (controlling for fall scores) and (b) the indirect effect of classroom age composition on children's language and literacy gains through classroom engagement. To formally test for mediation, we used the INDIRECT command in Mplus, which tests for mediation by taking the product of coefficients. We will test for the indirect effect whether or not we observe direct associations between the predictors and outcomes because of the existence of potential suppressors (MacKinnon, Krull, & Lockwood, 2000; Preacher & Hayes, 2008).

In the models with classroom engagement factors, the 4 factors were included simultaneously with correlated residuals. For each model, we included 2 out of the 3 classroom age indicators as predictors, with the third serving as the reference category. We used the same-age group (i.e., 4-year-old group) and the younger age group (i.e., 2/3-year-old group) as reference groups sequentially. The models with the younger age group (i.e., 2/3-year-old age group) as the reference category yielded no more significant findings than what was found in the models with the same-age group (i.e., 4-year-old group) as the reference category. Thus, for simplicity, we only presented results from the latter set of models. All models adjusted for the child- and classroom-level covariates. Finally, because all continuous variables were standardized to have a mean of 0 and a standard deviation of 1, all reported coefficients correspond to standardized betas.

Results

Age composition and classroom engagement

To begin, we first tested the associations between classroom age composition and the 4 dimensions of children's classroom engagement. As shown in Table 3, classroom age composition was *not* significantly associated with children's positive engagement with peers and tasks (β = |0.02 – 0.08|). Classroom age composition was significantly related to children's positive engagement with teachers and negative engagement. More specifically, 4-year-olds in classrooms with more younger peers demonstrated less positive engagement with teachers as compared with children in classrooms with more same-age peers ($\beta = -0.21$, $P < 0.001$). Additionally, 4-year-olds in classrooms with more older peers demonstrated less negative classroom engagement relative to children in classrooms with more same-age peers ($\beta = -0.12$, $P < 0.001$).

Table 3
Associations between classroom age composition, classroom engagement, and children's language and literacy gains.

	Predictor	
	Younger peers (vs. same-age peers)	Older peers (vs. same-age peers)
Outcome	B(SE)	B(SE)
Individual classroom engagement		
Positive engagement with teacher	−0.21 (0.06)***	−0.08 (0.05) +
Positive engagement with peers	0.08 (0.06)	0.04 (0.04)
Positive engagement with tasks	0.02 (0.05)	0.05 (0.04)
Negative engagement	−0.07 (0.05)	−0.12 (0.03)***
Children's language and literacy skills		
Receptive vocabulary	−0.01 (0.03)	−0.03 (0.03)
Expressive vocabulary	−0.00 (0.02)	0.01 (0.02)
Phonological awareness	−0.07 (0.04)	−0.00 (0.04)
Print knowledge	−0.05 (0.04)	0.00 (0.03)

Note. Younger peers = 2- or 3-year-old. Same-age peers = 4-year-olds. Older peers = 5-year-olds.
Models controlled for child-level covariates (age, gender, race/ethnicity, child language in English, maternal education, household income, household size, father living at home, number of children under 18 years old, the time between pre- and post-test), classroom-level covariates (teacher's gender, age, race/ethnicity, years of education, years at current program, intervention condition, class size, average classroom income-to-needs ratio, racial/ethnic percentage, percentage of girls in classroom, percentage of children with IEP/IFSP, percentage of children with limited English, Head Start, public school pre-K), and site locations.
All the coefficients can be interpreted as standardized betas given that all the continuous variables had a mean of 0 and standard deviation of 1 after the standardization. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, $+P < 0.10$.

Age composition, classroom engagement, and children's language and literacy learning

Having established the variation in classroom engagement attributed to classroom age composition, we next examined the associations between classroom age composition and the 4 language and literacy outcomes, separately. Results from these analyses revealed that there were no significant relations between classroom age composition and 4-year-olds' language and literacy outcomes (β = |0.00 – 0.07|; see Table 3). In other words, regardless of whether 4-year-olds were in classrooms serving a greater number of younger, same-age, or older peers, they demonstrated comparable gains in expressive vocabulary, receptive vocabulary, phonological awareness, and print knowledge.

Despite the lack of significant direct associations, we tested the mediating roles of children's individual classroom engagement, as there is growing consensus that significant direct effects are not a prerequisite for testing for indirect effects (MacKinnon et al., 2000; Preacher & Hayes, 2008). As shown in Table 4, children's positive engagement with teachers was positively associated with their receptive vocabulary gains ($\beta = 0.08$, $P < 0.01$), whereas children's negative engagement was negatively related to their gains in print knowledge ($\beta = -0.06$, $P < 0.05$). A test of indirect effects indicated that the pathway from children's receptive vocabulary through positive engagement with teachers was significant ($\beta_{\text{indirect}} = -0.02$, $P < 0.05$). In other words, 4-year-olds in classrooms with more younger peers demonstrated fewer gains in receptive vocabulary in part because they exhibited less positive engagement with their teachers.

To ensure that the results were robust to other potential confounds, we estimated 2 sets of supplemental models controlling for 1) instructional quality and content (see Supplemental Tables 1 and 2) and 2) children's learning behaviors (see Supplemental Tables 3 and 4), separately. Our focal findings did *not* change with the inclusion of these covariates. In addition, to ensure that our results were not sensitive to the use of FIML to address missing data, we reestimated our models using complete case data. Results from these complete case analyses were similar to our results reported above (see Supplemental Tables 5 and 6).

Discussion

Understanding how preschool experiences shape children's language and literacy skills is critical, as these early skills shape children's later reading abilities (Whitehurst & Lonigan, 1998), which in turn, have lifelong impacts on health and economic well-being (McLaughlin et al., 2014). However, previous studies suggest only a small-to-modest influence of preschool experiences captured at the classroom level on children's skill gains (Burchinal, 2018). Thus, researchers have begun to focus on the role of children's classroom engagement (Chien et al., 2010; Sabol et al., 2018). However, the factors that shape classroom engagement remain unclear. Accordingly, we focused on one aspect of the classroom environment, namely, classroom age composition, and explored how it shapes children's classroom engagement. We also investigated whether children's classroom engagement mediates the links between age composition and language and literacy gains. Taken together, our work demonstrates the potential role of classroom age composition in shaping 4-year-olds' classroom engagement and the significant,

Table 4
Direct and indirect coefficients for classroom engagement as mediators of the associations between classroom age composition and children's language and literacy outcomes.

	Outcome			
Predictor	Receptive vocabulary B(SE)	Expressive vocabulary B(SE)	Phonological awareness B(SE)	Print knowledge B(SE)
Positive engagement with teacher as the mediator				
Teacher → child outcome	0.08(0.03)**	0.04(0.02)	−0.02(0.04)	0.02(0.03)
Younger vs. same → Teacher → child outcome	−0.02(0.01)*	−0.01(0.01)	0.00(0.01)	−0.00(0.01)
Older vs. same → Teacher → child outcome	−0.01(0.00)	−0.00(0.00)	0.00(0.00)	−0.00(0.00)
Positive engagement with peers as the mediator				
Peer → child outcome	0.02(0.03)	0.04(0.02)	0.05(0.04)	0.03(0.03)
Younger vs. same → peer → child outcome	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Older vs. same → peer → child outcome	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Positive engagement with tasks as the mediator				
Tasks→ child outcome	0.00(0.03)	−0.02(0.03)	0.05(0.05)	−0.01(0.04)
Younger vs. same→ task → child outcome	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Older vs. same→ task→ child outcome	0.00(0.00)	−0.00(0.00)	0.00(0.00)	0.00(0.00)
Negative engagement as the mediator				
Negative→ child outcome	−0.05(0.03)+	−0.03(0.02)	0.03(0.04)	−0.06(0.03)*
Younger vs. same → negative → child outcome	0.00(0.00)	0.00(0.00)	−0.00(0.00)	0.00(0.00)
Older vs. same → negative → child outcome	0.01(0.00)	0.00(0.00)	−0.00(0.01)	0.01(0.00)+

Note. Younger peers = 2- or 3-year-old. Same-age peers = 4-year-olds. Older peers = 5-year-olds.
Models controlled for child-level covariates (age, gender, race/ethnicity, child language in English, maternal education, household income, household size, fathers' living at home, number of children under 18 years old, the time between pre- and post-test), classroom-level covariates (teacher's gender, age, race/ethnicity, years of education, years at current program, intervention condition, class size, average classroom income-to-needs ratio, racial/ethnic percentage, percentage of girls in classroom, percentage of children with IEP/IFSP, percentage of children with limited English, Head Start, public school pre-K), and site locations.
All the coefficients can be interpreted as standardized betas given that all the continuous variables had a mean of 0 and standard deviation of 1 after the standardization. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, $^{+}P < 0.10$.

albeit small, mediating effect of classroom engagement in linking classroom age composition and receptive vocabulary.

We found that 4-year-olds in classrooms with more younger peers demonstrated less positive engagement with teachers compared to children in classrooms with more same-age peers. On the contrary, being with more older classmates was associated with less conflict with teachers and peers and less off-task behaviors. These findings align with previous studies suggesting that variability in classroom age composition can make it challenging for teachers to incorporate individualized instructional content and provide high quality interactions for older children (Ansari, 2017; Kuger et al., 2016). We extended previous work by further illustrating how classroom age composition explains variance in children's individual classroom experiences, including their proximity-seeking behaviors and communication with teachers, peer conflict, and task disengagement. Our findings also support the sociocultural theory (Vygotsky, 1978) and the social-learning theory (Bandura, 1986), which indicate that younger children can benefit from being with older classmates since they gain more opportunities to observe and model socially desired skills. However, previous empirical findings are mixed in this regard, with most suggesting largely nonsignificant associations (Ansari et al., 2016; Bell et al., 2013). One reason for these discrepancies between our study and the extant literature may be our specific focus on children's interactional behaviors observed in classrooms. When taken together, the documented, albeit small, associations between classroom age composition and classroom engagement call for more nuanced studies on classroom processes and resources (e.g., curriculum and activities, teacher qualifications) that may function as a potential way to design mixed-age classrooms in ways that meet all children's needs.

Contrary to our expectations, we did not find any significant associations between classroom age composition and 4-year-olds' positive engagement with peers and tasks. There are several plausible explanations for these nonsignificant findings. First, developmental theory suggests that peer effects, including the effect of classroom age composition, are more likely to manifest through the indirect pathway of teachers compared to peers (Wilkinson & Fung, 2002; Wilkinson, Parr, Fung, Hattie, & Townsend, 2002). The indirect transmission of peer effects through teachers may be particularly distinct in preschool (Purtell & Ansari, 2018), given that preschoolers engage less in cooperative play and more in solitary and parallel play (Howes & Matheson, 1992). Thus, regardless of the age composition of classrooms, the extent to which preschoolers are able to initiate and maintain positive engagement with peers may not change, given the infrequent reciprocal interactions between peers at this age (Howes & Matheson, 1992). Similarly, because preschoolers spend a larger share of the day in individual play (Justice et al., 2021), the extent to which children are engaged with tasks is more likely to vary, and these variations include the degree of teachers' involvement and activity settings (Vitiello & Williford, 2020). Moreover, children's own characteristics (e.g., disruptiveness, receptive vocabulary, and effortful control) also contribute to their task engagement (Vitiello & Williford, 2020). Compared with the above factors, the ages of children's classmates may play a less important role.

The second major contribution of this study involved the effort to unpack the mediating role of classroom engagement in linking classroom age composition to children's language and literacy gains. A number of studies have examined the association between classroom age composition and children's learning outcomes (Ansari et al., 2016; Bell et al., 2013; Moller et al., 2008; Purtell & Ansari, 2018), but these studies have not focused on the mechanism underlying this association. Thus, we extended previous work by demonstrating that children's positive engagement with teachers plays a mediating role in the links between age composition and children's receptive vocabulary development. Echoing the ecological developmental framework (Howes, 2000), a higher proportion of younger classmates may have interfered with the age-appropriate instructional content and positive interaction older children received from teachers, which in turn, provided fewer opportunities for them to learn receptive vocabulary from teachers. This explanation is speculative but an important direction for future research. However, there is indirect support for this hypothesis

from other work. For example, studies have suggested that children in classrooms with more younger peers are more likely to experience both less and lower quality language stimulation and didactic instruction (Ansari, 2017; Wilkinson & Fung, 2002), which are critical for children's language growth (Cabell et al., 2015; Sabol et al., 2018). Nevertheless, this significant, albeit small, mediating effect indicates that there are, in fact, potential 'indirect' pathways linking mixed-age classroom configuration to children's learning outcomes. The detected pathway through classroom engagement in the current study may be a malleable target for intervention, especially given the longstanding concerns about mixed-age classrooms and the infeasibility to separately serve children by age group due to the economic constraints in some programs.

Despite the indirect pathway discussed above, it is important to note that *no* significant direct pathway from classroom age composition to the 4 language and literacy outcomes was found. Even though the findings are largely null, the standardized coefficients for children's literacy skills |0.05–0.07| are on par with some of the extant literature that examines classroom factors and children's language and literacy learning (|0.03–0.07|; Burchinal, 2018). Given that no single aspect of the classroom environment is likely to explain children's language and literacy skill development, small effect sizes, like that of classroom age composition, are still important (Kraft, 2020).

Limitations and future directions

Overall, this study adds to the extant literature by highlighting the role of classroom engagement in explaining the ways in which classroom age composition may shape children's language and literacy gains. Nonetheless, the conclusions of this study should be interpreted in light of some limitations. First, the study sample is not nationally representative, which limits the generalizability of our conclusions. Accordingly, replication with different samples is necessary before firm conclusions are drawn about the links between classroom age composition and children's classroom engagement along with their language and literacy development. With that said, however, the dataset used for the present study included programs from 8 states and different types of publicly funded preschool programs (Hamre et al., 2012; Pianta et al., 2017), and included a large number of families that were ethnically diverse and low-income.

Second, as part of the sampling frame, priority was given to 4-year-olds, and thus, study findings do not address the experiences of older or younger children. However, if 4-year-olds had less optimal experiences and academic gains in classrooms with a larger proportion of younger peers, as suggested in both the current study and previous studies (Ansari et al., 2016; Guo, Tompkins, Justice, & Petscher, 2014; Moller et al., 2008), this finding itself is noteworthy given the widespread use of mixed-age classrooms. Importantly, given the lack of information on the classroom engagement and learning outcomes of 3-year-olds and 5-year-olds in the current study, and the limited and mixed findings on these 2 age groups in previous studies (Ansari, 2017; Foster, Burchinal, & Yazejian, 2020.; Justice et al., 2019), further work is needed to understand how these processes unfold for 3-year-olds and 5-year-olds. In addition, using more nuanced measures to collect information on all children's exact age is also an important step for future research. Our measure of classroom age composition only evaluated nominal age categories, which limited our ability to capture the heterogeneity of children's exact ages in the classroom.

Third, the measures of classroom engagement only assessed the general behavioral patterns of children's engagement with the classroom environment, without differentiating engagement in different activity settings (e.g., whole group, small group, free play) and activity content (e.g., language and literacy, math, science). The sampled classrooms spent a substantial (but varied) amount of time on language and literacy activities ($M = 0.33$, $SD = 0.25$), which suggests that future studies should consider the extent to which children's classroom engagement varies as a function of the time spent on language and literacy activities. It is also worth noting that the observation of classroom engagement in the current study only sampled children during a single day, which may not be able to accurately capture the stability and change of their classroom engagement throughout the preschool year (Vitiello et al., 2012). More intensive observations at multiple time points throughout the school year are needed in the future. Nevertheless, the inCLASS is one of the few measures that reflect children's individual classroom experiences. Moreover, compared with other existing measures, the inCLASS provides information on engagement with 3 core development resources: teachers, peers, and tasks, and contains both positive and negative aspects. Nonetheless, more research should focus on exploring how classroom age composition affects individual children's classroom experiences using more fine-grained measurements. Although this study specifically examined classroom engagement, other pathways may exist. For example, with more refined observations of children's engagement with teachers, researchers would be able to more precisely investigate the quality and quantity of teacher-child interactions in different contexts and test whether these account for the associations between classroom age composition and children's language and literacy development. Alternatively, the combined nature of children's negative engagement with teachers, peers, and tasks may mask unique influences. Future research should examine these 3 components separately to untangle their specific pathways from classroom age composition.

Implications and conclusions

With the above-mentioned limitations and future directions in mind, our work has implications on the implementation of mixed-age classrooms in preschool. Ultimately, the current study demonstrated that for 4-year-olds, being in preschool classrooms with more younger classmates was associated with lower positive engagement with teachers, which could be further transmitted to less receptive vocabulary gains. However, being with more older classmates was associated with lower negative engagement. Combined with the lack of direct links between classroom age composition and children's language and literacy outcomes, these findings suggest that mixed-age classrooms may not be necessarily related to children's inferior learning outcomes; it is the intermediating classroom experiences that may determine whether mixed-age classrooms work or not. In light of the mediating role of classroom engagement documented here, continued attention should be paid to improving teachers' skills in facilitating 4-year-olds' positive engagement and minimizing negative engagement in these classrooms.

Author contribution

Qingqing Yang: Conceptualization, Methodology, Software, Writing - original draft, Writing - Review & editing. Caroline P. Bartholomew; Conceptualization, Methodology, Software, Writing - review & editing. Arya Ansari: Conceptualization, Supervision, Writing - review & editing. Kelly M. Purtell: Conceptualization, Supervision, Writing - review & editing.

Conflict of interest

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ecresq.2022.01.001.

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