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Classroom age composition and rates of change in school readiness for children enrolled in Head Start

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ABSTRACT

Despite policy and theoretical support for mixed-age classrooms in early childhood, research examining associations between age-mixing and children's outcomes is inconclusive and warrants further investigation, particularly in preschools serving children who are at risk for poor adjustment to formal schooling. One recent study conducted in preschool classrooms serving low-income children found negative associations between age-mixing and children's social and cognitive development. The current study extended this research by examining associations between classroom age composition (variability in ages of children in the classroom) and low-income preschool children's rates of change in school readiness. The sample consisted of 4417 preschool children enrolled in 207 classrooms in a large, diverse urban Head Start program. Multilevel modeling was employed to examine the main effect of classroom age composition, as well as the interaction between classroom age composition and children's age, as predictors of children's rates of change in emergent literacy, emergent numeracy, social and emotional skills, and approaches to learning. In contrast to previous research, classroom age composition was not associated with school readiness outcomes. This study contributes to the conflicting literature examining the associations between age mixing and children's school readiness and calls for a future research agenda to examine age mixing in context that is focused on sorting out these conflicting results. In the meantime, policymakers should consider other relevant factors when making decisions regarding mixed-age classrooms, such as family preference or the capability for teachers to individualize instruction to children based on their individual needs.

Children from low-income families are at risk for poor adjustment to formal schooling because of the multiple stressors associated with living in poverty (e.g., family stress, lack of desirable housing, exposure to community violence; Duncan, Brooks-Gunn, & Klebanov, 1994; McLoyd, 1998). National attention has been paid to identifying and promoting emergent competencies, broadly referred to as school readiness, that can support school success as these vulnerable children enter kindergarten (Blair, 2002; Kagan, Moore, & Bredekamp, 1995). Research suggests that participation in high quality early childhood educational experiences can promote school readiness, particularly for low-income children (Shonkoff & Phillips, 2000).

In the past, preschool programs have served predominantly four- to five-year-old children. However, there has been a recent increase in the enrollment of three-year-old children in early childhood education programs nationally (NIEER, 2007). The percentage of three-year olds in the U.S. enrolled in an early childhood program has increased from 31% in 2005 to 51% in 2011, while the percentage of four-year olds enrolled in early childhood programs has risen from 68% to 74% (NIEER, 2005, 2011). More research is needed to examine the practices implemented to incorporate the increasing representation of younger children in early childhood programs and how these practices influence children's school readiness, particularly in programs serving low-income children (Bowman, Donovan, & Burns, 2001). The present study examined the association between classroom age composition (i.e., variability in children's ages in the classroom) in Head Start and children's rates of change across the preschool year in multiple domains of school readiness, including emergent literacy, emergent numeracy, social and emotional skills, and approaches to learning.

Head Start, the nation's largest federally funded early childhood program serving low-income children, emphasizes the importance of social learning in young children and strives to promote children's cognitive and social skills by encouraging social interaction in the classroom (Head Start Performance Standard 1304.21 (a) (4) (iii), U.S. Department of Health and Human Services, 2006; Zigler & Bishop-Josef, 2006). One of the practices in Head Start programs commonly used to support social interaction is the creation

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of mixed-age (MA) classrooms by including children as young as three years and as old as five years in the same classroom. This practice is in contrast to creating same-age (SA) classrooms that separate children by age group. Many educators advocate for the use of MA classrooms, including the National Association for the Education of Young Children (NAEYC), as a developmentally appropriate practice in early childhood programs (Katz, Evangelou, & Hartman, 1990). Over two decades ago, NAEYC published a book entitled "The Case for Mixed-Age Grouping in Early Education" making MA classrooms a common and accepted practice in early childhood education. In this book, Katz et al. (1990) argued that mixed ages in the classroom enhance the socialization of young children. More specifically, they stated that this approach mimics family and neighborhood groupings, encourages positive social development (e.g., leadership) through peer tutoring, and promotes cognitive development by integrating children of different ability levels within the classroom learning context.

Current developmental theories also support the notion that social interactions with adults and peers play an important role in children's development. Bronfenbrenner and Morris (1998) state that proximal processes – interactions between the child and his or her environment – are the primary mechanisms through which children develop. In this model, school readiness skills are fostered through children's interactions with teachers as well as with peers of varying skill levels (Hamre & Pianta, 2007). Specifically, Vygotsky (1978) promoted the idea of the "zone of proximal development" in which children are pushed slightly beyond the limits of their knowledge by a more competent and experienced person. A more competent partner, such as an older peer or adult, is able to scaffold learning by allowing the less competent learner to practice more advanced reasoning at a level not yet attainable independently. These theoretical models support the idea that MA classrooms would be an ideal environment in which young children of different ages and abilities can learn from one another within the social context of the classroom.

Despite practical and theoretical support for the benefits of children in mixed-age groups in early childhood classrooms, empirical support is less consistent. In fact, one recent study conducted in low-income preschool classrooms in a public school district found evidence for the negative association between age mixing and children's developmental readiness skills (Moller, Forbes-Jones, & Hightower, 2008). Experts warn that the benefits of MA classrooms are only possible when implemented correctly, such as through scaffolding appropriate social interaction between children and individualizing instruction based on children's ages (NIEER, 2007). Given recent national increase in three-year olds entering preschool, as well as concerns over the current implementation of curricular approaches appropriate to MA classrooms, research is needed to carefully examine the role of MA classrooms on children's school readiness, particularly in programs such as Head Start serving children at risk.

1. Research on mixed-age classrooms

Most of the research examining the influence of MA classrooms on children's outcomes was conducted in the late 1970s through the 1990s. This body of research has produced conflicting results making it difficult to draw clear conclusions about the positive or negative influence of classroom age composition on children's social and academic outcomes, particularly for programs serving low-income populations. Some studies have indicated that age mixing is associated with positive development in children, including less segregated play across age and gender and more complex forms of play for younger children (e.g., Field, 1982; Goldman, 1981). In contrast, other research has highlighted potential costs of age mixing, such as less complex play for older children and increased aggression in younger children (e.g., Langlois, Gottfried, Barnes, & Hendricks, 1978; Lougee, Grueneich, & Hartup, 1977; Roopnarine et al., 1992).

Longitudinal studies extend these conflicting findings. Results provide evidence that younger and older children's play behaviors in MA classrooms were more similar to begin with, remained similar over time, and that all children in MA classrooms engaged in more frequent but less complex forms of social interaction (Bailey, Burchinal, & McWilliam, 1993; Roopnarine et al., 1992; Winsler et al., 2002). Other research suggests that the social environment of the preschool classroom changed throughout the school year as children become more familiar with one another and that the benefits of MA classrooms, particularly the higher levels of social integration, faded over the year (Winsler et al., 2002). Bailey et al. (1993) examined the influence of mixed-age classrooms on children's rates of change in developmental skills. In this study, they found that children in MA classrooms showed significantly higher rates of change than children in SA classrooms in multiple domains of development, including cognitive, social, and physical domains. Also, younger children in MA classrooms scored higher than younger children in SA classrooms throughout the year. However, they found that the advantages for younger children in MA classrooms decreased over time, and by age five, they were reversed, such that older children in SA classrooms were outperforming older children in MA classrooms.

To date, the practical application of research on MA classrooms particularly within programs serving low-income children has been hindered by these inconsistent research findings, as well as methodological limitations. Research comparing SA and MA classrooms has examined children's outcomes using varying measures of social development (e.g., social interaction and social-cognitive play behaviors) or global constructs of children's cognitive development. These outcomes are not necessarily applicable to the contemporary view of school readiness which encompasses multiple and specific domains of development including cognitive (e.g., early literacy, numeracy skills) and behavioral (e.g., social and emotional, approaches to learning) skills (Blair, 2002; Kagan et al., 1995). In addition, previous research did not account statistically for the hierarchical structure of the data (e.g., children being nested within classrooms). When children are studied within the classroom context, such as is the case when examining the classroom-level influences on child-level outcomes, the assumption of independence between observations is violated and this non-independence must be taken into account when conducting statistical analyses (Raudenbush & Bryk, 2002). Most importantly, existing research has included small samples of predominantly Caucasian children from middle- to high-income families, limiting the generalizability of these findings to more ethnically and socioeconomically diverse populations.

One recent study conducted by Moller et al. (2008) examined classroom age composition in urban preschools serving predominantly low-income children. Moller et al. (2008) operationalized classroom age composition in an innovative way. Using a large sample of primarily MA classrooms, they defined classroom age composition as the variability of ages within the classroom making classroom age composition a continuous rather than dichotomous variable. They also utilized multilevel modeling to examine the main effect of classroom age composition, as well as differential effects for younger and older preschool children, on teacher-rated cognitive, social, and motor skills in the spring while controlling for fall scores. They found a main effect of classroom age composition indicating that as the age variability in the classroom increased (i.e., in classrooms with a greater degree of age mixing), children's skills decreased. They did not find differential effects for younger and older children. This finding is particularly relevant for programs such as Head Start since it suggests that age-mixing may not be a beneficial practice for public program serving low-income children.

Overall, the study by Moller et al. (2008) advanced previous research by defining classroom age composition as a continuous variable and by employing multilevel modeling to examine this variable in relation to children's outcomes within classrooms serving low-income children. However, this study was limited by its use of ordinal-level measurement of children's global developmental skills that are not in alignment with the current conceptualization of school readiness (Kagan et al., 1995). In addition, children's development was measured at two time-points limiting the ability to examine rates of change in children's skills across time. The present study addressed these limitations and extended the work of Moller et al. (2008).

2. Present study

The purpose of the present study was to extend previous research examining the association between classroom age composition and children's school readiness using data from a large Head Start program in the Southeastern United States. This specific Head Start program only consists of centers that enroll three- and four-year-old children and utilize MA classrooms. Based on the operationalization presented by Moller et al. (2008), classroom age composition was defined as a continuous variable (i.e., variability in children's ages in the classroom) and was examined in classrooms that were predominantly mixed-age. School readiness was measured at multiple times across the academic year in order to examine rates of change in school readiness across one year of Head Start. In addition, children were assessed using a tool that provides interval-level measurement of children's abilities in specific cognitive and social domains of school readiness, including emergent literacy, emergent numeracy, social and emotional skills, and approaches to learning. The main effect of classroom age composition on rates of change on this comprehensive set of school readiness skills was examined. Interactions between children's age and classroom age composition were tested to examine the differential associations of classroom age composition for younger and older children in the classroom.

In addition to classroom age composition, important child-level demographic characteristics, including age, gender, ethnicity, dual-language learner status, and special needs status were examined. Previous research has found that these child-level influences contribute to children's abilities in social and academic domains of school readiness. Specifically, research has shown that older children and girls have better school readiness skills across academic and social domains (Bulotsky-Shearer, Domínguez, Bell, Rouse, & Fantuzzo, 2010; Coolahan, Fantuzzo, Mendez, & McDermott, 2000); however, research on gender differences in preschool has also produced conflicting results (Davies & Brember, 1999). Child ethnicity, particularly for minority ethnic groups, has been associated with school readiness outcomes (Lee & Burkam, 2002). However, research examining differences across cultural and ethnic groups are also inconclusive (Fantuzzo, Coolahan, Mendez, McDermott, & Sutton-Smith, 1998). Finally, previous research has identified two additional risk factors for poor school readiness: children whose home language is not English and children who have been identified with a special need (August & Shanahan, 2008; Fantuzzo et al., 1999). Specific research questions consisted of the following:

(1) What is the association between classroom age composition, as well as other child-level demographic characteristics, and children's rates of change in school readiness?
(2) Is the association between classroom age composition and rates of change in school readiness moderated by children's age?

It was expected that children would improve in all school readiness domains across the year. With regard to the associations between classroom age composition and children's school readiness outcomes, we hypothesized that if the findings of Moller et al. (2008) were replicated in our sample, there would be a significant negative main effect of classroom age composition on children's rates of change in school readiness skills; greater variability in ages within the classroom would be associated with lower rates of change across the school year for all children in the classroom. Alternatively, if other research findings were replicated (Blasco, Bailey, & Burchinal, 1993; Field, 1982; Goldman, 1981; Howes & Farver, 1987; Urberg & Kaplan, 1986), classroom age composition would be positively associated with rates of change in school readiness, particularly for younger children; greater variability in ages would be associated with higher rates of change in school readiness for younger children in these classrooms.

3. Method

3.1. Participants

Children in this study were selected based on their enrollment in a large, urban Head Start program in the Southeastern United States during the 2008–2009 academic year. During this school year, this Head Start program served 7301 children in 316 classrooms across 77 centers. Centers averaged approximately 4 classrooms per center (SD = 3.89). The average age of children at the beginning of the school year was 47.7 months (SD = 7.12). Approximately half of the children were female (51.9%). Children in the program were predominantly Black or African American (57.1%) and Hispanic or Latino (42.1%) with a small percentage of children identified as White or Other (0.8%). In addition, there were a significant number of children who were identified as dual-language learners (43.0%). Approximately 12.4% of children in the program were suspected or identified as having one or more special need (e.g., speech or language impairment, physical impairments, developmental delays, and emotional or behavioral disorders). Information regarding special needs status was acquired through administrative data from Head Start that indicated the children who had been referred for special needs services (suspected) or diagnosed with one or special need (identified). In the 2008–2009 academic year, 98% of children in this Head Start program met the federal income requirement (less than $22,050 for a family of four) for enrollment in Head Start, confirming a sample of low-income children.

In this Head Start program, teachers enter school readiness data for their entire classroom either online through a web-based system or on paper. Only classrooms in which the teacher entered their students' school readiness assessments online were examined because only information from these classrooms was available to researchers. During this school year, 207 of the 316 (66%) teachers entered their classroom school readiness information online. To ensure that children spent at least one month in the classroom (to appropriately examine the association of classroom composition and children's outcomes), children who dropped out of the program before October 1, 2008, and children who enrolled in the program after May 1, 2009 were excluded from the analyses. Due to these constraints, the final sample consisted of 4417 children in 207 classrooms across 50 centers. This sample was very similar to the larger population of children in this Head Start program with respect to the demographic variables. The average age of children at the beginning of the school year was 47.5 months (SD = 7.13). Approximately half of the children were female (52.2%). Children were predominantly Black or African American (53.4%) and Hispanic or Latino (45.5%), with a small percentage of children identified as White or Other (1.1%). Approximately 46.4% of children were identified as dual-language learners, and 12.8% of children were suspected or identified as having one or more special need.

3.2. Measures

Classroom age composition. In accordance with Moller et al. (2008), classroom age composition was calculated using the standard deviation of children's ages in months at the beginning of the school year. Each classroom received a score indicating the standard deviation of ages around the mean age of the classroom. In the Moller et al.'s study, classroom age composition was also calculated using the range of children's ages in the classroom. For this study, the standard deviation of ages within the classroom was believed to be a better measure of variability because it is less influenced by extreme outliers than the range (Howell, 2007). Therefore, the standard deviation was used for this study and not the classroom age range.

School readiness. Children's school readiness scores were assessed using the Galileo System for the Electronic Management of Learning (Galileo; Bergan et al., 2003). The Galileo is a teacher measure used to track children's rates of change in eight school readiness domains. Each scale contains a series of skills divided into sub-skills that are observable in the classroom. Each sub-skill includes a set of items for which the teacher indicates whether the skill is "learned" or "not learned" for each child in the classroom. A skill is considered "learned" if the teacher has observed the child performing the skill at least three times. Therefore, teachers do not use their own judgments about children's abilities and instead indicate whether they have observed a child demonstrate a specific skill at least three times. In this Head Start program, teachers are trained to observe their children throughout the day and keep anecdotal notes of their progress in these specific school readiness domains. Using these observations and notes, teachers enter children's skills into a web-based system as often as they like throughout the year with a minimum requirement of three times per year (fall, winter, and spring). Teacher's entry of children's skills into this web-based system is monitored by each center's curriculum specialist to ensure that these observations are recorded throughout the year.

Based on an item response theory (IRT) model (Thissen & Steinberg, 1986), children are given interval-level ability scores for each school readiness domain. In an interval-level scale, differences between scores are meaningful because a unit increase is equivalent across the entirety of the scale (Osterlind, 2006, pp. 169–170). This scale of measurement is different from the measure used in the Moller et al. (2008) study in which teachers rated children's skills on a 5-point Likert-scale and ratings were averaged across items. The measure used in the Moller et al. (2008) study is considered ordinal-level of measurement where the order of scores is meaningful but the difference between scores is not (Osterlind, 2006, pp. 168–169). Statisticians caution researchers against performing parametric methods of analysis that utilize means and differences between means (such as linear regression and multilevel modeling) with data on an ordinal scale (Munzel & Bandelow, 1998; Shah & Madden, 2004). The interval-level measure used in the current study represents an important extension of the Moller et al. (2008) study. With these interval data, differences in children's ability scores are meaningful allowing us to calculate rates of growth using change in scores across the year.

The developers of the Galileo have standardized the scales on a large sample of ethnically diverse preschool children attending early childhood programs in multiple states (Bergan, Burnham, Feld, & Bergan, 2009). The mean of the ability distribution is 500 with a standard deviation of 50 for all eight readiness domains allowing for direct comparisons across domains. The Galileo has demonstrated strong internal consistency indicated by a Cronbach's alpha coefficient of .94 (Bergan et al., 2009). Four of the eight Galileo scales were used for this study: Language and Literacy, Early Math, Social and Emotional Skills, and Approaches to Learning. These scales were chosen because they represent key cognitive and social domains of school readiness (Denham, 2006; Domínguez & Greenfield, 2009; Duncan et al., 2007; Whitehurst & Lonigan, 1998).

The Language and Literacy scale includes skills such as knowledge of receptive and expressive vocabulary, early reading abilities, and alphabet knowledge. The Early Math scale includes skills such as counting, sorting, and identifying shapes and patterns. The Social and Emotional Skills scale assesses children's engagement in social relationships including their skills in cooperation, conflict resolution, and self-control. The Approaches to Learning scale includes learning-related behaviors, such as initiative, curiosity, attention, and persistence. Each subscale demonstrates high internal consistency with Cronbach's alpha coefficients of .97, .95, .97, and .94 for the Language and Literacy, Early Math, Social and Emotional Skills, and Approaches to Learning scales, respectively (Bergan et al., 2009). Factor analytic studies conducted by the developers of the Galileo support the structure of the scales. All subscales within each scale were found to reflect a single underlying factor with subscale loadings for all four scales ranging from .38 to 1.00 (Bergan et al., 2009).

3.3. Procedure

Data were obtained through a larger data integration project in collaboration with the Head Start program. The purpose of the larger project was to integrate two large administrative databases programmatically collected by the Head Start program. Prior to acquiring data, approval for the project was acquired from the University Institutional Review Board, the director of Head Start, and the Head Start Parent Policy Council. The two large databases included a child and family information database consisting of child and family demographic information (date of birth, gender, ethnicity, primary and secondary home language, special needs status, etc.) and a database consisting of children's school readiness information assessed by the Galileo. Because there was no unique identifier across all databases, children's data were linked across the databases to create an integrated database using Microsoft Integrated Services. The databases were linked using the following information: first name, last name, date of birth, gender, and race/ethnicity combinations. This linking strategy was based on similarities at a 95% confidence match. Records that had matches were separated into a master table for that particular assignment and then joined at the end of the process. Duplicate cases were identified within the process and removed.

Child and family demographic information was extracted from the program's demographic database. According to procedures established by the Head Start program, parents or guardians report on child and family demographic information at enrollment which is then entered into the database by Head Start administrative staff. Information is updated when a child's enrollment information changes. For the school readiness assessment data, teachers enter the Galileo data for each child into a web-based system at least three times throughout the school year. Once data between these two databases were linked, all identifying information was stripped from the file prior to conducting analyses.

3.4. Data analytic plan

Multilevel modeling (MLM) was used to examine both child-level and classroom-level variables and their associations with children's rates of change in school readiness scores. A series of three-level models were conducted using HLM6 (Raudenbush, Bryk, Cheong, & Congdon, 2004). First, a fully unconditional model for each of the four school readiness outcomes was specified to ensure that there was a significant proportion of variance within children, between children, and between classrooms. Second, unconditional growth models were specified to determine if children's school readiness scores changed significantly across the academic year. Finally, the child- and classroom-level variables were entered as predictors of children's baseline scores and their rates of change in school readiness over the year. Missing data were handled using full information maximum likelihood (FIML) which uses all available data when estimating parameters (Hancock & Mueller, 2006; Kline, 2005) and is recommended for use in developmental research (McCartney, Burchinal, & Bub, 2006).

Level 1 (time). Time (the number of days that had passed since the beginning of the school year) was entered as a predictor of the intra-individual variability in children's school readiness scores. Examining the effect of time on children's school readiness scores determined if their scores changed significantly across the school year.

Level 2 (child demographic characteristics). Age, gender, ethnicity, dual-language learner status, and special needs status were entered as predictors of the variability between children's scores within each classroom. Age was calculated in months at the beginning of the school year. Gender (0 = male, 1 = female), dual-language learner status (0 = primary language is English, 1 = primary language is something other than English), and special needs status (0 = no special needs, 1 = one or more identified special needs) were dummy-coded. For ethnicity, Black/African American was set as the reference group, and Hispanic and Other were included as predictors. All Level 2 predictors were centered at the group mean in order to create parameter estimates for child-level variables that were free from between-classrooms variation (Enders & Tofighi, 2007). If the variance terms associated with the random effects of the child-level variables were not statistically significant, the effect of this variable on school readiness did not vary at the classroom-level. It was expected that the random effects associated with age would vary across classrooms based on previous literature indicating classroom composition can influence children's outcomes differently based on their age (Blasco et al., 1993; Howes & Farver, 1987; Urberg & Kaplan, 1986). However, no rationale was available for the random effects associated with the other child demographic characteristics. Therefore, non-significant variance components were fixed to zero in order to create a more parsimonious model; significant variance components were freely estimated.

Level 3 (classroom age composition). Classroom age composition was entered as a predictor of the variability in children's scores that is associated with differences between classrooms. The main effect of classroom age composition was tested on children's baseline scores as well as their rates of change. In addition, the cross-level interactions between children's age and classroom age composition were tested on baseline scores and rates of change to determine if the associations between classroom age composition and school readiness were different for younger and older children.

Table 1
Descriptive statistics for school readiness domains.

	N	Average # timepoints	Mean	*SD*
School readiness domain				
Emergent Literacy	4251	8.06	492.19	67.142
Emergent Numeracy	4249	4.96	501.14	62.302
Social and Emotional Skills	4237	9.38	483.71	60.237
Approaches to Learning	4256	8.97	539.85	57.118

Note. Scores represent developmental item response theory (IRT) scores ($M = 500$ and $SD = 50$).

4. Results

4.1. Descriptive statistics

Classroom age composition, the standard deviation of children's ages in month ($M = 6.70$, $SD = 0.98$), ranged from 3.23 to 9.10 and was examined for skewness and kurtosis. No assumptions were violated. The distribution of classroom age composition in this sample was examined. This variable was normally distributed and indicated that, on average, most children in the classroom were within a little more than 12 months of age from each other (within 6.7 months below the mean and 6.7 months above the mean). However, this varied considerably with many classrooms having the majority of children within <12 months of age from each other and many classrooms having children within >12 months of age from each other. This finding confirmed that this sample consisted of MA classrooms. Descriptive statistics for the school readiness domains can be found in Table 1. For each domain, multilevel models were built in a series of steps as described previously.

4.2. Multilevel modeling results

Unconditional models identified a significant amount of variance in children's school readiness at each of the three levels. Variance distributions for the four school readiness domains are in Table 2. Results for the final models are in Table 3.

Level 1 (time). Unconditional growth models were analyzed to determine if children changed in their school readiness scores across the year. For this model, the intercept is interpreted as the mean of teachers' ratings of children's school readiness at the beginning of the school year (baseline score), and the slope is interpreted as the daily average rate of change in school readiness across the year. For all school readiness domains, the intercept was statistically significant, and the slope was both significant and positive. These models demonstrated that children experienced significant improvement in emergent literacy, emergent numeracy, social and emotional skills, and approaches to learning across the year. The addition of the time variable accounted for 73.5–81.5% of the variance in school readiness attributable to differences within children (see Table 4). The random effects associated with the intercept and slope were statistically significant for all models, indicating the appropriateness of entering predictors at Level 2 and Level 3.

Level 2 (child demographic characteristics). Child demographic characteristics (age, gender, ethnicity, dual language learner status, and special needs status) were added at the intercept

Table 2
Distribution of variance for school readiness domains.

	Level 1 within-children	Level 2 between-children	Level 3 between-classrooms
School readiness domain			
Emergent Literacy	40%	32%	29%
Emergent Numeracy	41%	34%	25%
Social and Emotional Skills	38%	34%	28%
Approaches to Learning	40%	38%	22%

Table 3
Multilevel linear modeling results for final model.

Fixed effects Parameter	Emergent Literacy Estimate (SE)	Emergent Numeracy Estimate (SE)	Social Emotional Estimate (SE)	Approaches to Learning Estimate (SE)
Intercept (γ_{000})	439.4739* (2.77)	459.6700* (2.28)	438.6821* (2.77)	491.2384* (2.53)
Age composition (γ_{001})	1.7237 (2.86)	1.1687 (2.33)	1.5858 (2.85)	1.5350 (2.59)
Age (γ_{010})	3.8526* (0.18)	3.3650* (0.17)	3.6262* (0.19)	4.1416* (0.17)
Age × age composition (γ_{011})	0.3448 (0.20)	0.2039 (0.19)	0.2296 (0.20)	0.3950* (0.19)
Gender (γ_{020})	7.2392* (1.55)	4.9512* (1.35)	6.7629* (1.55)	5.7370* (1.55)
Hispanic (γ_{030})	−3.4514 (3.19)	−1.8755 (2.78)	−4.1771 (3.17)	−1.6251 (3.16)
Other (γ_{040})	−4.4052 (7.68)	0.4496 (6.67)	−10.1598 (11.83)	−4.3531 (10.35)
Dual language learner (γ_{050})	−0.8921 (2.82)	−1.2397 (2.45)	−0.7079 (2.82)	−2.9903 (2.82)
Special needs (γ_{060})	−0.3263 (2.90)	0.4720 (2.83)	3.2231 (2.90)	4.1256 (2.91)
Slope (γ_{100})	0.3640* (0.02)	0.3639* (0.02)	0.3164* (0.01)	0.3369* (0.01)
Age composition (γ_{101})	0.0107 (0.02)	0.0091 (0.02)	0.0026 (0.02)	0.0032 (0.01)
Age (γ_{110})	−0.0011 (0.00)	0.0026* (0.00)	−0.0040* (0.00)	−0.0065* (0.00)
Age × age composition (γ_{111})	−0.0011 (0.00)	−0.0003 (0.00)	−0.0005 (0.00)	−0.0015* (0.00)
Gender (γ_{120})	−0.0056 (0.01)	0.0005 (0.01)	−0.0085 (0.01)	−0.0075 (0.01)
Hispanic (γ_{130})	0.0258* (0.01)	0.0213 (0.01)	0.0302* (0.01)	0.0144 (0.01)
Other (γ_{140})	−0.0005 (0.03)	−0.0008 (0.03)	0.0236 (0.04)	0.0272 (0.03)
Dual language learner (γ_{150})	−0.0095 (0.01)	0.0054 (0.01)	−0.0154 (0.01)	0.0036 (0.01)
Special needs (γ_{160})	−0.0468* (0.01)	−0.0291* (0.01)	−0.0387* (0.01)	−0.0364* (0.01)
Random effects				
Level 1 (σ^2)	360.5959	295.5038	361.4710	306.0367
Level 2				
Intercept ($\tau_{\pi 00}$)	1820.9076*	1313.0884*	1878.2119*	1931.8461*
Slope ($\tau_{\pi 11}$)	0.0191*	0.0155*	0.0187*	0.0186*
Level 3				
Intercept ($\tau_{\beta 00}$)	1439.6414*	963.4903*	1447.4993*	1198.7428*
Intercept/age ($\tau_{\beta 01}$)	3.5990*	3.8661*	4.0427*	3.2117*
Intercept/other ($\tau_{\beta 04}$)	–	–	2986.94132*	2199.4068*
Intercept/special needs ($\tau_{\beta 04}$)	–	200.6564*	–	–
Slope ($\tau_{\beta 10}$)	0.0470*	0.0452*	0.0421*	0.0247*
Slope/age ($\tau_{\beta 11}$)	0.0001*	0.0001*	0.0001*	0.0001*
Slope/other ($\tau_{\beta 14}$)	–	–	0.0182*	0.0176*
Slope/special needs ($\tau_{\beta 13}$)	–	0.0061*	–	–

Note. Age represents children's age in months. Gender (male = 0 and female, = 1), Black/African American, Hispanic/Latino, Other, dual language learner, and special needs are dummy-coded. Approaches to Learning, Social Emotional, Early Math, and Language and Literacy are developmental level scores (*M* = 500 and *SD* = 50).
* $p \leq 0.05$.

and slope to examine the associations between these variables and children's school readiness at the beginning of the year, as well as their rates of change in school readiness across the year. The intercept (γ_{000}) is interpreted as the average baseline school readiness score for children at the mean age for their group and in classrooms with an average ratio of gender, ethnicities, dual-language learners, and children with special needs. Age and gender were significant predictors of baseline scores for all school readiness domains, with older children and girls rated as having higher school readiness scores at the beginning of the year than younger children and boys.

The slope (γ_{100}) is interpreted as the daily average rate of change in school readiness for children at the mean age for their group and in classrooms with an average ratio of gender, ethnicities, dual-language learners, and children with special needs. For emergent literacy, ethnicity and special needs status were predictors of rates of change, with Hispanic children showing higher rates of change in emergent literacy than Black children and children with special needs showing lower rates of change in emergent literacy than children without special needs. For emergent numeracy, age and special needs status were predictors of rates of change, with older children showing higher rates of change in emergent numeracy than younger children and children with special needs showing lower rates of change in emergent numeracy than children without special needs. For social and emotional skills, age, ethnicity, and special needs status were predictors of rates of change, with older children and children with special needs demonstrating lower rates of change in social and emotional skills than younger children and children without special needs, and Hispanic children showing higher rates of change in social and emotional skills than Black children. For approaches to learning, age and special needs status were predictors of rates of change, with older children showing higher rates of change in approaches to learning than younger children and children with special needs showing lower rates of change in approaches to learning than children without special needs. The variance terms associated with age at the intercept and slope were statistically significant in all models, indicating that the effect of age on baseline scores and rates of change in school readiness varied at the classroom-level. Additionally, the variance term associated with "Other" ethnicity was statistically significant for social and emotional skills and approaches to learning, and the variance term

Table 4
Percent of variance explained by predictors.

	Time	Child demographic characteristics	Classroom age composition
School readiness domain			
Emergent Literacy	80.0%	34.0%	–
Emergent Numeracy	81.5%	36.2%	–
Social and Emotional Skills	73.5%	31.8%	–
Approaches to Learning	76.4%	31.8%	0.2%

Note. Values indicate the percentage of variance of the outcome that is explained by the predictor variables at each level. Values for classroom age composition are shown only when it was a significant predictor.

associated with special needs status was significant for emergent numeracy. All other variance terms were not significant and were fixed to zero. The addition of the Level 2 variables accounted for 31.8–36.2% of the variance in school readiness attributable to differences between children (see Table 4).

Level 3 (classroom age composition). Finally, classroom age composition was entered as a predictor of children's baseline scores and rates of change in school readiness to examine the association between classroom age composition and children's school readiness at the beginning of the year as well as their rates of change across the year. In addition, cross-level interactions between classroom age composition and children's age were specified at the intercept and the slope. Level 2 results did not change with the inclusion of the Level 3 variables. For the three-level model, the intercept (γ_{000}) is interpreted as the average baseline score in school readiness for children at the mean age for their group and in classrooms with an average ratio of gender, ethnicities, dual language learners, and children with special needs as well as in classrooms with an average classroom age composition. The slope (γ_{100}) is interpreted as the average rate of change in school readiness for children at the mean age for their group and in classrooms with an average ratio of gender, ethnicities, dual language learners, and children with special needs as well as in classrooms with an average classroom age composition. The slopes for emergent literacy and emergent numeracy ($\gamma_{100} = 0.364$, $SE = 0.02$, and $p < 0.001$; $\gamma_{100} = 0.364$, $SE = 0.02$, and $p < 0.001$) were equivalent to a rate of change of 11.1 points (almost a quarter of a standard deviation) per month. The slope for social and emotional skills ($\gamma_{100} = 0.316$, $SE = 0.01$, and $p < 0.001$) was equivalent to a rate of change of 9.6 points (approximately a fifth of a standard deviation) per month. Finally, the slope for approaches to learning ($\gamma_{100} = 0.337$, $SE = 0.01$, and $p < 0.001$) was equivalent to a rate of change of 10.3 points (approximately a fifth of a standard deviation) per month. For approaches to learning, there were no main effects associated with classroom age composition. However, there were statistically significant cross-level interactions between children's age and classroom age composition at the intercept ($\gamma_{011} = 0.395$, $SE = 0.19$, and $p = 0.04$) and at the slope ($\gamma_{111} = 0.001$, $SE < 0.01$, and $p = 0.04$). The interaction at the intercept (where Time = 0) indicates that teachers rated older children in classrooms with a larger age composition as having better approaches to learning at baseline as compared to older children in classrooms with a smaller age composition. The interaction at the slope can also be interpreted as a three-way interaction between time, children's age, and classroom age composition. Younger children in classrooms with a larger age composition showed higher rates of change over time in approaches to learning as compared to younger children in classrooms with a smaller age composition. However, for the final model the addition of classroom age composition explained less than 1% of the variance attributable to differences between classrooms, indicating a very small effect (see Table 4). For emergent literacy, emergent numeracy, and social and emotional skills, classroom age composition was not a statistically significant predictor of the intercept or the slope, and there were no significant cross-level interactions between children's age and classroom age composition.

5. Discussion

This study examined the association between classroom age composition and children's rates of change in multiple domains of school readiness in a sample of preschoolers from a large, urban Head Start program. In this municipal Head Start program, our data confirmed that MA classroom practices were being used but that the extent to which classrooms contained children of mixed ages varied considerably across the program. Consistent with hypotheses, the results show that children experienced significant improvements in emergent literacy, emergent numeracy, social and emotional skills, and approaches to learning across one academic year. Children's age and gender were significantly associated with initial skill levels in these domains early in the year; whereas age, ethnicity, and special needs status was associated with children's rates of change across the year. There were no main effects of classroom age composition on rates of change in any domain of school readiness. However, statistically significant cross-level interactions between children's age and classroom age composition indicated that the association between classroom age composition and children's approaches to learning was dependent on the age of the child. However, the effect size of these interactions was very small limiting the practical significance of this finding. Therefore, classroom age composition was not associated with children's school readiness in this sample of Head Start classrooms when considering practical significance.

This study adds to the literature examining the influence of a common practice in early childhood educational programs, the use of MA classrooms, on children's school readiness using a rigorous multilevel modeling methodological approach. This study is the second to examine the association of classroom age composition, as defined by the standard deviation of ages in the classroom, and school readiness in low-income preschool classrooms. It is the first study to use interval-level data and examine the association between age classroom age composition and *rates of change* in a comprehensive set of readiness skills, including the domains of emergent literacy, emergent numeracy, social and emotional skills, and approaches to learning. Findings from a previous study (Moller et al., 2008) suggesting that a greater degree of age mixing in low-income preschool classrooms was negatively associated with children's competencies were not replicated. Instead, our study provided evidence suggesting that classroom age composition was not negatively associated with school readiness in a representative sample of classrooms from a large, urban Head Start program. These results contribute to a controversial literature attempting to disentangle the effects of age mixing in preschool classrooms. In this discussion, we summarize the findings as they contribute to existing literature and suggest important next steps.

5.1. Child-level influences

The results for age and gender were consistent with previous research showing that older children and girls display higher school readiness skills than younger children and boys (Bulotsky-Shearer, Fantuzzo, & McDermott, 2008; Mendez, McDermott, & Fantuzzo, 2002). At the beginning of the year, older children and girls were rated as having higher skills in all domains of school readiness. However, for social and emotional skills and approaches to learning, younger children developed these skills at a higher rate than older children throughout the year. That younger children were catching up to older children is encouraging given that social and emotional skills and approaches to learning are important prerequisites for academic learning in preschool (Domínguez & Greenfield, 2009; Raver, 2002).

Age did not predict rates of change in emergent literacy, indicating that older children maintained the initial advantage they demonstrated in this domain throughout the year. For emergent numeracy, older children began the year with higher scores and grew at faster rates than younger children. One potential reason for this finding is that teachers may be directing instruction in early reading and math toward older children transitioning to kindergarten because they have already developed the ability to interact socially and pay attention during learning situations. In addition, rates of change in the domains of social and emotional skills and approaches to learning could be more important for younger children; once they acquire foundational social, emotional, and approaches to learning skills they then can engage more successfully in cognitively demanding domains of learning, such as literacy and numeracy skills (Layzer, Goodsen, & Moss, 1993). However, future research is needed to support this conclusion. For all domains of school readiness, gender did not predict rates of change, indicating that boys did not catch up with girls who started out the year with higher levels of school readiness skills. These findings extend previous literature documenting gender differences in preschool (Bulotsky-Shearer et al., 2010; Stowe, Arnold, & Ortiz, 2000) by showing that these differences are maintained throughout the preschool year.

The findings for ethnicity and dual language learner status were not as clear. While there were no differences among ethnicities at the beginning of the year, Hispanic children experienced higher rates of change than Black children in the domains of emergent literacy and social and emotional skills. One potential explanation for why Hispanic children are growing at a faster rate, particularly in the domains of early literacy and social and emotional skills, is that many Hispanic children speak Spanish as their primary home language and are acquiring English-speaking skills at the same time as they are acquiring other school readiness skills (Butler & Hakuta, 2004; Oller & Eilers, 2002). However, in our study, dual language learner status did not predict baseline scores or rates of change in school readiness. In our study, children's dual language learner status was based on parent report of primary and secondary language. This indicator may not have been sensitive enough to the variability in language exposure and future studies using more direct measures of dual language learner status or English language proficiency would provide more accurate information. Research attempting to explain differences across cultural groups has been restricted by methodological limitations, such as lack of valid measures for particular cultural groups (Fantuzzo et al., 1998). Future research is needed to investigate the effects of ethnicity and dual-language learner status on school readiness.

In addition, our study found that children with special needs did not start out the year below their non-special-needs peers, but that they developed school readiness skills at a lower rate. This finding is consistent with federal regulations and research emphasizing the importance of identifying children with special needs as early as possible in their schooling (Fantuzzo et al., 1999; IDEA, 1997). Research suggests that children from low-income families who are identified with special needs are at disproportionate risk for poor outcomes early on and later in life (Lavigne et al., 1996). Because Head Start is the largest provider of services to low-income children with special needs in the United States (Schwartz & Brand, 2001), it is critical for future work to examine how assessment tools used by teachers in Head Start classrooms can facilitate early identification of children with difficulties in school readiness in order to intervene in these domains across the school year.

5.2. Classroom age composition

Contrary to previous research in classrooms serving low-income children (Moller et al., 2008), classroom age composition was not negatively associated with children's school readiness. In fact, no main effect of classroom age composition was found. This finding is surprising considering that children's peers and the classroom social environment are very influential on children's experiences in the classroom (Bulotsky-Shearer, Dominguez, & Bell, 2012; Early et al., 2006; Hamre & Pianta, 2001). It is important to note that while classroom age composition provided information on the peer characteristics in the classroom, it did not provide information on what was happening in the classroom on a daily basis. The same degree of age mixing in the classroom could manifest itself differently based on the structure of the classroom, the social environment of the classroom, and many other factors. In addition, previous research that has examined the social interactions of children in MA classrooms over time shows that the social environment of MA classrooms changed throughout the year, with children more likely to interact with their same-age peers towards the end of the school year (Winsler et al., 2002).

The role of classroom age composition could be better understood if more information on the classroom context was included in analyses. For example, it would be important to examine the quality with which teachers support peer interactions within the classroom as a context for learning and the amount of opportunities that teachers provide for shared, cooperative learning activities within the classroom. A combination of high classroom quality and a large age composition might create the most beneficial environment for fostering children's school readiness (Hamre & Pianta, 2005). In addition, classroom age composition in combination with other classroom contextual variables might be associated children's school readiness differently at the beginning, middle and end of the year (Winsler et al., 2002). Future research should examine the interactive effects of classroom quality and classroom age composition on low-income children's school readiness.

A statistically significant interaction was found between children's age and classroom age composition on approaches to learning; however, the effect size was very small limiting its significance for educational practice. Specifically, this finding indicated that younger children in classrooms with a larger age composition were rated by their teachers as demonstrating higher rates of change in approaches to learning than younger children in classrooms with a smaller age composition. This finding is consistent with other research which found that younger children benefit by being in a MA classroom (Blasco et al., 1993; Howes & Farver, 1987; Urberg & Kaplan, 1986). Younger children in classrooms with a larger age composition could potentially benefit throughout the year from exposure to older peers in terms of the development of learning-related behaviors such as initiative, curiosity, attention, and persistence. Approaches to learning are not only malleable in preschool children but may also serve as a protective factor for children at risk for poor academic outcomes (Domínguez & Greenfield, 2009; McWayne & Cheung, 2009; Schaefer & McDermott, 1999). If replicated with noteworthy effect sizes in other studies, this finding may have important implications for educators who are interested in intervention with low-income children.

6. Limitations and future directions

The present study contributed to the literature on classroom age composition by using a representative sample of children and classrooms from a large, urban Head Start program in the Southeast. In addition, this study utilized multilevel modeling and interval-level measurement to examine the associations between child- and classroom-level variables and baseline scores and rates of change in multiple domains of school readiness. Despite these strengths, some limitations should be acknowledged. First, the generalizability of the findings is limited to populations of predominantly African-American and Hispanic children from low-income families living in urban areas. Future research should replicate these findings in samples of children from other diverse groups and geographic areas. In addition, the association between classroom age composition and school readiness may be dependent on other child-level variables besides age. For example, some literature has shown that MA classrooms influence children with special needs differently than typically developing children (Bailey et al., 1993; McWilliam & Bailey, 1995). Given that Head Start enrollment includes at least 10% of children with special needs, future research should consider the classroom experiences and school readiness outcomes of children with special needs who are enrolled in MA classrooms.

Second, the school readiness domains were measured using teachers' reports of children's skills in these domains. Therefore, children's scores in school readiness may, in part, reflect teachers' perceptions of children's abilities. Research suggests that teachers' ratings of children's skills often contain variance attributable to teacher characteristics and perspectives (Mashburn, Hamre, Downer, & Pianta, 2006). However, the Galileo is designed to measure teacher's direct observations of children's skills in the classroom and does not ask the teacher to make inferences or judgments about children's abilities. In addition, the Galileo is used as the program-wide school readiness assessment for this Head Start program and has been used in research studies that have been published in peer-reviewed journals (e.g., Domínguez, Vitiello, Maier, & Greenfield, 2010; Iruka, 2008; Vitiello, Moas, Henderson, Greenfield, & Munis, 2012). Future research should incorporate multiple methods and sources for measuring children's school readiness skills, such as direct assessment and observational techniques.

Finally, due to the archival nature of the data employed in this study, additional classroom-level variables that may be associated with children's school readiness were unavailable for analyses. Numerous other classroom-level variables should be examined, such as classroom quality or teacher characteristics that have been shown to be associated with school readiness skills (Early et al., 2006; Hamre & Pianta, 2001). In addition, other classroom composition variables or peer characteristic should be examined, such as the composition of gender, ethnicities, dual-language learners, children with special needs, as well as the level of problem behavior or positive social interaction in the classroom (e.g., Bulotsky-Shearer et al., 2012). Future research could also investigate moderating influences of these classroom-level variables on the relationship between classroom age composition and school readiness.

7. Conclusions and implications

This study contributes important findings to the controversial literature attempting to understand the influence of classroom age composition on school readiness for low-income children enrolled in early childhood programs. With the majority of research on MA classrooms limited by methodological issues and conducted prior to the more recent comprehensive approach to defining school readiness, the more recent Moller et al. (2008) study calls into the question the common practice of MA classrooms. If replicated, these findings have serious consequences for early childhood practices. Our study, which both replicates and enhances the methodological approach of Moller et al. (2008), provides strong contradictory evidence to their findings of a negative association of MA classrooms with school readiness. In contrast to the Moller et al. (2008) study, our study shows that age mixing was not negatively associated with school readiness; in fact, it was not significantly associated school readiness at all.

When considering our study alongside the Moller et al. (2008) study, our findings point to a critical next step for future researchers to move beyond calculating classroom age composition and to observe classroom age composition in context by examining the dynamics of interactions in these classrooms. Such studies can reveal characteristics of classrooms that enhance the benefits of mixed-age classrooms and characteristics that do not. Until these associations are better understood within the context of the classroom, policymakers should use other relevant factors when making decisions regarding mixed-age classrooms, such as the preference of the families being served as well as the capability for teachers to individualize instruction based on children's specific needs. Factors such as the teacher–child ratio within the classroom as well the curricular strategies used in the program and the professional development associated with these strategies should be considered when determining how to structure classrooms with regard to age composition. With the recent national increase in three-year olds entering preschool, it is necessary to carefully examine the implications of age mixing within the classroom context, particularly in programs such as Head Start serving children at risk.

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