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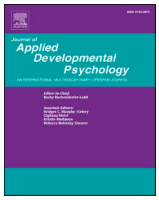

Peer experiences in the preschool classroom: Contribution to children's academic development

Hui Jiang *, Laura M. Justice, Tzu-Jung Lin, Kelly M. Purtell, Jing Sun

The Ohio State University, United States

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ABSTRACT

The present study examined the relations between two aspects of peer experiences in preschool classrooms and children's math and literacy development during kindergarten transition. Based on the theoretical framework of classroom ecology model, peer experiences were represented by classroom social network and teachers' grouping preferences. The outcomes included standardized math and literacy assessments collected from three time-points, fall of preschool, spring of preschool and fall of kindergarten. The analytical sample included 367 children recruited from 47 preschool classrooms located in two large school districts. Children completed peer-nomination tasks to characterize the classroom social network and teachers completed questionnaires to describe their grouping preferences. We conducted a multilevel longitudinal model to estimate the effects of classroom-level predictors on the trajectories of skill growth. We found that indices of classroom social network – density and centralization – were significantly associated with math and literacy development: more dense classrooms positively predicted math and literacy development whereas more centralized classrooms negatively predicted math and literacy development. Teachers' attention to children's skill levels in creating grouping structure was positively associated with math and literacy development. These findings indicate that young children's peer experiences are potentially important indicators of classroom quality, as they are associated with children's academic development over the course of preschool year into kindergarten transition.

Introduction

Presently, more than two-thirds of 3- to 5-year-old children participate in center-based preschool (McFarland et al., 2019), a timeframe corresponding to the most rapid development of social and linguistic competencies in the human lifespan (Huttenlocher, 2009). The preschool classroom is a primary social context that provides children with their first opportunities to experience various social interactions and develop social relationships with peers (Johnson et al., 1997; Ladd, Herald, & Andrews, 2006). Children build their social relationships with peers voluntarily through fun-seeking play, verbal and non-verbal interaction in tasks and problem-solving, and involuntarily through teachers' management in the classroom during learning and non-learning activities. A multitude of studies have found that early peer experiences can impact child development in the long term (e.g., Bulotsky-Shearer et al., 2012; Coplan & Arbeau, 2009; Lin, Justice, Paul, & Mashburn, 2016), and there is a great deal of interest among scientists and policy-makers to identify aspects of peer experiences that are critical to children's early learning trajectories, including early math and literacy competencies (e.g., Mashburn, Justice, Downer, & Pianta, 2009).

In the present study, we conceptualize children's peer experiences as influenced by two key dimensions of the integrative model of classroom ecology, put forth by authors such as Bierman (2011) and Gest and Rodkin (2011). First, peer experiences are directly impacted by their *peer social network* composed of intricate interactions and relationships formed in the classroom. Peer social network provides a context that shapes children's individual interactions and relationships (Bramoullé, Djebbari, & Fortin, 2009), which in turn drive development (Bronfenbrenner & Morris, 2007). Second, peer experiences are influenced by *teacher practices*, which represents teachers' approaches to organizing and delivering instruction within the classroom, as well as their attitudes that transcend the classroom's academic and social milieu. In particular, teachers' grouping strategies and practices, such as pairing children based on certain criteria, are pivotal in forming children's peer experiences (Sheridan, Williams, & Samuelsson, 2014). Through group activities, young children engage with their peers in ways that likely influence one another's development of a range of skills.

* Corresponding author.
E-mail address: jiang.200@osu.edu (H. Jiang).

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The present study was designed to further understand the extent to which peer experiences (peer social network and teacher practices) in preschool classrooms contribute to children's development in math and literacy through the kindergarten transition. We juxtaposed two influencers of peer experiences, namely the classroom *friendship network* and *teachers' grouping preferences*. The classroom friendship network is a proxy for peer social network and composed of the friendship relationships children voluntarily established with peers of their choice, whereas teachers' grouping preference is a proxy for teachers' grouping strategies that can act as an intervening force in fostering children's learning opportunities. Given the sheer volume of time children spend interacting with their classmates in the preschool setting (Chaparro-Moreno, Justice, Logan, Purtell, & Lin, 2019), we surmise that these two metrics of children's peer experiences can be mapped onto the two distinct dimensions of the classroom ecological model, peer social network and teacher practices, which are highly influential to children's academic development.

Preschool peer experiences and child development

In the United States, peer experiences in the preschool classroom is of great importance as a very unique schooling context: much of children's time is relatively un-structured with children allowed a great deal of autonomy to select peers with whom to interact (Vitiello, Pianta, Whittaker, & Ruzek, 2020). In a recent cross-sectional study of 553 students in 46 preschool and 46 kindergarten classrooms, systematic observation of children's time showed that preschoolers spent nearly 50% of their time in free play or centers; by comparison, kindergarteners spent about 10% of their time in this manner (Justice, Jiang, Purtell, Lin, & Ansari, 2021). Typically, during free play and center activities, children have considerable agency in determining with whom they interact with and for how long. Even at these very young ages, however, children show systematic preferences in selecting with whom they will interact, preferring to interact with those who are most like them in terms of age, gender, abilities, and behaviors (e.g., Lin et al., 2016; Martin et al., 2013). As they exert these preferences, children create peer social networks within the classroom setting comprising the social ties among them and the values attached to these ties (Ahn, Garandeau, & Rodkin, 2010).

The peer effect literature focused on preschool populations revealed strong associations between peer experiences and children's cognitive and language development (Henry & Rickman, 2007; Justice, Logan, Lin, & Kaderavek, 2014; Mashburn et al., 2009). For instance, the skill levels of classroom peers had direct and positive effects on children's cognitive, reading, and language development above and beyond children's initial skills (Henry & Rickman, 2007). Preschool children with more highly skilled classmates experienced greater language skill development in preschool years (Mashburn et al., 2009). The average language skills of classmates in the fall significantly predicted preschool children's language skills in the spring, and such peer effects were the most influential for children with disabilities (Justice et al., 2014).

Although peer experiences in preschool classrooms have been extensively studied (e.g., Chen, Justice, Tambyraja, & Sawyer, 2020; Lin et al., 2016; Vitiello et al., 2020), many studies operationalize peer experiences as peer skills averaged or accumulated among classroom peers, whereas how preschool peer experiences operate through the lens of peer social networks only became to emerge in the recent decade. In the context of the current study, peer social networks refer to the complex web of social relationships and interactions that develop among children within the educational setting. These networks encompass various forms of social connections, including friendships and affiliative ties, as well as potential conflicts and rivalries. A handful of studies have demonstrated the importance of these early peer social networks (e.g., positive play behaviors in preschool) to young children's social development (Coelho, Torres, Fernandes, & Santos, 2017) and academic development (e.g., preschool competency, DeLay, Hanish, Martin, & Fabes, 2016). In addition, research studying preschoolers with developmental language disorder found that these children tend to have smaller peer social networks and are more likely to be isolated by peers (Chen et al., 2020). These studies suggest that preschool classrooms can either foster or hinder children's learning experiences through the complex socialization processes in which peer social networks develop and evolve (Daniel, Santos, Antunes, Fernandes, & Vaughn, 2016).

Classroom friendship network

In the present study, we examined the dimension of peer social network through the lens of friendship ("friendship network") for its possible influence on academic development. Using friendship networks as a proxy for peer social networks in studies of preschool children and classrooms offers several advantages. First, friendships are the primary dyadic positive peer connections established in early classroom settings (Bukowski, Laursen, & Rubin, 2019). Second, friendship networks provide a more stable structure than networks of other positive peer relationships or interactions (e.g., play network; Bukowski et al., 2019). Moreover, friendships often serve as the primary context for children's interactions and collaborations in this age group (Guralnick, Neville, Hammond, & Connor, 2007). As a result, focusing on friendship networks can facilitate the understanding of key patterns, trends, and influences of peer social networks in preschool.

Studies suggest that successful friendships formed in classrooms can contribute to children's development and adjustment, impacting their social, emotional, and academic outcomes. Classroom friendships provide students with a sense of relatedness, belonging, and emotional support, which collectively serve to create a safe and secure context for children to learn (Ladd, Kochenderfer, & Coleman, 1997). Friendship relationships also provide essential contexts for children to acquire and practice various social skills and emotional competencies, such as empathy, cooperation, and conflict resolution (Bukowski et al., 2019). In addition, friends tend to socialize various learning-related behaviors and academic skills (Cooc & Kim, 2017; Lin et al., 2016), which are linked to improved academic performance and engagement (Ladd, 1990). For kindergarten children, having friends in school has also been associated with more positive attitudes towards school (Ladd & Coleman, 1997).

In the present study, the classroom friendship network was represented by two network measures: density and centralization. Based on the network diffusion perspective (McCormick & Cappella, 2015), *density* refers to the degree of connectedness in a network. High-density networks may accelerate children's acquisition of certain social values or behaviors in learning activities and socialization (Ahn et al., 2010; Chen et al., 2020). *Centralization* represents the social hierarchy of a classroom network (Ahn et al., 2010). A highly hierarchical classroom is characterized by a cohesive core of children surrounded by peripheral subgroups, which may worsen aggressive and deviant behaviors due to potential social norm of competition and social dominance (Mikami, Szwedo, Allen, Evans, & Hare, 2010). Consequently, negative behaviors in highly hierarchical classrooms may detract learning and adversely impact children's academic development (Bierman, 2011; Ladd, Ettekal, & Kochenderfer-Ladd, 2017). In the context of friendship networks, network density indicates the amount of reciprocal friendship relationships in a network, whereas network centralization refers to the extent of which friendship ties are concentrated around a few central individuals. Children in a denser network are more interconnected and share more balanced social interactions, which provides a heightened volume of opportunities for children to learn from and interact with each other (McCormick & Cappella, 2015). On the other hand, highly centralized networks may create barriers for peer communication and equilibrium in the classroom, leading to negative social behaviors and learning environment (Serdiouk, Rodkin, Madill, Logis, & Gest, 2015).

To date, much evidence concerning density and centralization of peer social networks has been focused on children in the primary grades

and adolescence (e.g., Ahn et al., 2010; Laninga-Wijnen, Ryan, Harakeh, Shin, & Vollebergh, 2018), yet we propose that these network parameters, as measures of the peer dimension of the integrative ecology model, are likely to have developmental significance for young children in the earliest years of schooling. Specifically, given extensive evidence showing the importance of friends to academic achievement (e.g., Gremmen, Dijkstra, Steglich, & Veenstra, 2017), we proposed that a denser and less-centralized preschool peer social network of friendships would be associated with accelerated development of math and literacy skills over the preschool year.

Teacher grouping preferences

Given the substantial amount of time available for children to exert their social preferences in preschool classrooms, peer experience in the classroom is driven primarily by children's preferences with respect to whom they seek to interact. However, teachers' instructional practices also mediate children's experience with peers by establishing specific grouping arrangements among dyads or small groups of children (Kim et al., 2020). Gest and Rodkin (2011) found that teachers' grouping practices were associated with the ratio of peer liking to disliking and the density of friendships. Recent research also suggests that children's development in preschool settings is influenced by both teachers and peers, which seem to operate independently (Yeomans-Maldonado, Justice, & Logan, 2019).

Although preschoolers spend considerable time in free play, recent evidence shows that they also experience considerable time in dyadic and small groupings of three or four children, representing as much as one-quarter of their classroom time (Justice et al., 2021; Vitiello et al., 2020). Teachers likely play a significant role in providing learning opportunities via various organizations of these smaller classroom groupings, such as suggesting two children who are close friends to work together, creating small groups of children who share similar academic abilities, or separating children displaying problem behavior (Gest & Rodkin, 2011). While preschoolers have the autonomy and ability to voluntarily establish groups of their choice, teachers' grouping practices also create opportunities for children to initiate verbal interactions, engage in learning activities, and imitate or learn from each other.

Bierman refers to teachers' strategic actions in creating these grouping structures as an 'invisible hand,' a term which serves to highlight the salient but poorly understood role that teachers play in affecting interactions among children (Bierman, 2011). For instance, descriptions of the practices of "exemplary teachers" have shown that master teachers use a range of grouping strategies across the day to foster children's collaborations (Duke, Cervetti, & Wise, 2018). This may reflect long-standing perspectives in early childhood education concerning the need to employ developmentally appropriate practices and to not disrupt children's agency in socialization and learning activities (Bredekamp & Copple, 1997). Recent reports also suggest the value of providing preschool children with structured small-group experiences to enhance their skill development (Lane, Gast, Shepley, & Ledford, 2015; Piasta et al., 2021). This is driven in part by longitudinal research showing that exposure to small-group instruction in preschool settings has long-term positive effects on early literacy development (Connor, Morrison, & Slominski, 2006). However, there is limited research on how teachers in preschool classrooms may intentionally use grouping strategies to influence children's learning opportunities and outcomes.

Despite the lack of attention to grouping structures in preschool settings, considerable research has examined the use of grouping structures in the early primary grades, especially ability-based groupings (Slavin, 1987). There are two prominent ability-based grouping strategies: same-ability grouping or mixed-ability grouping. Nearly two-thirds of primary-grade teachers in the United States use same-ability grouping structures to provide language-arts instruction, and they do so because they believe that these grouping structures contribute positively to teaching quality and student learning (Chorzempa & Graham, 2006). Same-ability grouping involves creating smaller groupings of students on the basis of their ability levels in a given content area, such as reading. In the early primary grades, teachers tend to rely on same-ability groupings because they perceive that they are better able to differentiate their instruction to meet students' instructional needs when they are taught in smaller groupings with peers whose skills are similar (Chorzempa & Graham, 2006; Patrick, 2020). Mixed-ability grouping assumes that working with peers with diverse academic knowledge and skills can stimulate greater ideas and perspectives, which then foster sense making and deep learning (Murphy et al., 2017; Wilkinson, Soter, & Murphy, 2010). Concerns about mixed-ability grouping often surround whether group learning is at the expense of high-ability children's learning opportunity (Mashburn et al., 2009).

Teachers also create groupings within the classroom for reasons other than ability. For instance, teachers may use grouping as a strategy of classroom behavior management, by reducing interactions among children who do not get along or enhancing interactions among children with shared interests. In turn, this can create a more positive classroom climate and peer community to promote constructive learning (Gest, Madill, Zadzora, Miller, & Rodkin, 2014; Gest & Rodkin, 2011). Likewise, teachers may use certain grouping strategies to facilitate interactions between children who are excluded from the peer social network (Gest et al., 2014). In this regard, teachers' grouping preferences can directly influence interactions and peer-learning opportunities for children who are experiencing exclusion. However, the extent to which teachers' specific grouping preferences may influence children's academic development in preschool settings is currently unknown.

The current study

Increasingly, education researchers are interested in how peer experiences may shape young children's academic development, as suggested by numerous studies of the peer effects phenomenon in early education settings (e.g., DeLay et al., 2016; Henry & Rickman, 2007; Justice et al., 2014; Mashburn et al., 2009). There is also interest in considering whether children's peer interactions may serve to represent the quality of preschool classrooms, namely as a characteristic of classrooms that influences children's academic-skill development. However, while there is an extensive body of work linking peer experiences to children's social and emotional development (e.g., Crick et al., 2006; Stenseng, Belsky, Skalicka, & Wichstrøm, 2014), less attention has focused on how these peer experiences may influence such academic skills as early math and literacy development (see Bierman, 2011). In the present study, we aimed to identify the unique influences of the peer experiences as represented by children's *friendship network* characteristics, as well as teacher practices as represented by *teachers' grouping preferences*, on children's academic development in preschool. By examining peer experiences from both children's (i.e., friendship networks reported by peers) and teachers' perspectives (i.e., teachers' grouping preferences), our findings are expected to inform practical guidelines for preschool teachers to design group-based activities that help them strategically navigate children's existing friendships and cultivate more positive friendships to maintain healthy and productive learning in preschools. Two research questions were addressed: (1) To what extent do classroom friendship networks' density and centralization influence preschool children's math and literacy development over an academic year? (2) To what extent do preschool teachers' grouping preferences influence children's math and literacy development over an academic year?

Method

Sample

The sample of classrooms, teachers, and children used to address the present research questions was derived from the Early Learning Network

project, a large federally funded project comprising cross-sectional and longitudinal methods designed to examine the effects of classroom experiences on children's academic and social development in preschool through third grade. The present sample consisted of 47 preschool classrooms enrolled in year 1 and year 2 of the parent project. Although we also sampled kindergarten through third-grade classrooms in the first year of the study, our focus in this study was specific to children's experiences in preschool, which for many children represent their first experiences with peers in classroom settings (Daniel et al., 2016).

Classrooms and teachers

A total of 47 preschool classrooms in a variety of program types (e.g., private programs, district-affiliated programs) in central Ohio were recruited from two large partnering school districts that served preschool to grade 12 students. The first partnering school district has over 22,000 students in 33 buildings located in rural, suburban, and urban settings. Students in the district are largely white (60%), although a non-trivial percentage of students are Black (15%), Asian (3%), or multi-racial (6%). Hispanic took up 16% of the student population. The second partnering school district serves over 20,000 students (75% white, 4% Black, 13% Asian, and 5% multi-racial; 3% Hispanic) in 24 buildings located mostly in the suburban setting.

As one of the partnering districts operated few preschool programs, the study team recruited heavily from across district boundaries to achieve target enrollment goals. Table 1 provides an overview of preschool classroom characteristics. We recruited 31 classrooms from the first district (District 1) and 16 classrooms from the second district (District 2). Forty-eight percent of classrooms were pre-kindergarten (pre—K) programs, serving children who were designated for kindergarten in the forthcoming year. The remainder were mixed-age classrooms primarily serving children between three and five years of age, although a small percentage of students were younger than three (two-year-old) or older than five (six- or seven-year-old). The mean class size was about 17 children ($SD = 4$), with a range of 12 to 29.

Table 1 also provides details about the teachers in these classrooms, who were variable in their age, years of experience, and demographic background. About three-fourths of the teachers had a bachelor's degree or higher, and teachers were all female and primarily white (98%).

Table 1
Descriptive information about teachers and classrooms (N = 47).

	Valid *N*	% or Mean	*SD*	Min	Max
Preschool Teacher Characteristics					
Teacher age (years)	46	39.24	9.71	22	60
Teacher's years of experience	45	13.43	9.12	2	31
Teacher's years of experience teaching preschool	43	8.61	6.99	1	31
Teacher gender: Female	45	100%			
Teacher early childhood certification	45	27%			
Teacher race and ethnicity: White, non-Hispanic	44	98%			
Teacher education level	45				
High school degree		13%			
Associate's degree		9%			
Bachelor's degree		64%			
Master's degree		13%			
Preschool Classroom Characteristics					
Class size	45	17.02	3.69	12	29
Serving pre-K age only (Same age classroom)	46	48%			
Five-day week program	46	28%			
Half day program	46	48%			
District	47				
District 1		66%			
District 2		34%			
Teachers' Grouping Preferences					
Academic-based grouping	44	1.10	0.55	0	2
Friendship-based grouping	43	0.99	0.55	0	2
Behavior-based grouping	43	1.69	0.35	1	2
Classroom Friendship Network					
Network density	46	0.07	0.05	0.00	0.19
Network centralization	46	0.11	0.05	0.00	0.24

Children

The study team recruited children from participating teachers' classrooms in the fall or winter of the year, depending on when a preschool program joined the study. The majority of classrooms (and children) joined in the fall of the school year, although an additional set of classrooms was recruited in the winter to increase the number of preschool-aged participants to reach the enrollment goal. To be included in the study, children needed to speak English at basic levels (so as to be able to complete assessment tasks) and have no severe disabilities that would limit their ability to complete assessments. Within-classroom participation was generally high, with an average of 71% of families (range = 41% ~ 100%) in any given preschool classroom consented to participate in direct assessments.

For the present study, we were primarily interested in children's growth in math and literacy skills as they progressed through preschool and into kindergarten. Therefore, we only included children in our analytical sample if they: (1) had data on math and literacy skills on at least two occasions from among three possible time-points (fall and spring of preschool and fall of kindergarten); and (2) were between three to five years of age in the fall of preschool year and were designated for kindergarten the following year. In total, the analytical sample consisted of 367 unique children from 46 preschool classrooms.

Details of the child sample and their families are shown in Table 2. In terms of race and ethnicity, the sample in our study was generally representative of the student population in the school districts (Chi-squared tests were non-significant). Fifty-five percent of the participating children from District 1 were white, 11% were Black/African American, 4% were Asian, and 13% were multi-racial. Moreover, 21% of the children were Hispanic. Among children recruited from the second district, 83% were white, 2% were Black, 7% were Asian, and 7% were multi-racial. Hispanic students took up 4% of the District 2 sample. However, compared to student demographics in Ohio, the study sample tended to under-represent Black/African American students (21% in the state) due to a lower consent rate among Black/African American families. In terms of socioeconomic status, the children came from backgrounds that varied substantially: about one-fourth of children resided in homes that were relatively lower-income ($30,000 or less annually household income) and one-fourth came from very advantaged homes ($160,000 or more).

Procedures

Teachers were recruited through informational meetings at preschools and childcare centers located within district boundaries. All children enrolled in classrooms with participating teachers were eligible to participate with caregiver consent. Caregivers also completed an initial screening questionnaire on their children and family background as part of the consent process. Enrolled children received age-appropriate books at every direct assessment timepoint, and caregivers received $10 after completing a family questionnaire in the spring of children's preschool year

The primary study procedure of relevance was conducting assessments with children. These were completed by professional research staff with extensive training and rigorous protocols. Before administering an assessment task with a child, staff would complete self-guided modules describing all aspects of the assessment (e.g., materials, scoring guidelines), and complete practice tests until achieving a predetermined accuracy level. The staff would also be observed giving the assessments in the field by a supervisor before being able to work

Table 2
Descriptive information about children and families in the analytical sample (n = 367).

	Valid *N*	% or Mean	*SD*	Min	Max
Child and Family Characteristics					
Child age in months (fall of preschool)	366	56.22	4.46	38	69
Child gender: Female	367	49%			
Child race	365				
White		68%			
Black/African American		7%			
Asian		5%			
Other		10%			
Multiracial		10%			
Child ethnicity: Hispanic	364	13%			
Mother's highest level of education	365				
Less than high school		13%			
High school diploma or GED		27%			
Associate's degree		7%			
Bachelor's degree		27%			
Graduate or professional degree		27%			
Family annual income	359				
$30,000 or less		28%			
$30,001 ~ $90,000		24%			
$90,001 ~ $160,000		23%			
$160,001 or more		25%			
Number of people in household	318	4.50	1.21	2	9
Number of children in household	318	2.47	1.17	1	9
Primary home language	366				
English only		80%			
Other language only		14%			
Multilingual		7%			
Child having an IEP (spring of preschool)	366	3%			
Free or reduced lunch (preschool)	310	30%			
Child Outcomes					
Math					
Fall of preschool	297	412.98	24.20	318	453
Spring of preschool	356	419.43	24.27	318	485
Fall of kindergarten	167	424.76	21.36	318	467
Pre-literacy					
Fall of preschool	300	343.43	29.43	264	494
Spring of preschool	358	355.06	31.79	264	500
Fall of kindergarten	169	362.07	23.62	293	457

Note. Children's math skills were assessed by *Woodcock Johnson Test of Achievement-III* (WJ; Woodcock et al., 2007) – Applied problems subtest, W scores. Children's literacy skills were assessed by WJ-Letter word identification subtest, W scores.

independently. All assessments took place during the school day in quiet locations and consisted of two blocks: (1) direct assessments of children's academic skills, and (2) tasks measuring children's executive functioning (not used in the current study) and a child interview. Staff would administer the two blocks in one or two sessions depending on scheduling, student attention, or teacher preference. All data were collected on tablets in digital *E*-forms and synced to the study database. The data management team then processed the data using SQL database code, and manually cleaned the data before they can be used in their current formats.

Measures

This study examines children's growth in math and literacy skills as a function of the classroom friendship network and teachers' grouping preferences. Children's math and literacy skills came from direct assessments; the friendship network measures came from children's self-report; and teachers' grouping preferences came from teachers' self-report. We discuss these measurement approaches here along with measurement of relevant covariates.

Children's math and literacy skills

The primary outcomes examined in the present study were children's math and literacy skills as assessed by two subtests of the norm-referenced and standardized *Woodcock Johnson Test of Achievement-III* (WJ; Woodcock, McGrew, & Mather, 2007): Applied Problems (AP) and Letter Word Identification (LWID). Both tests were given in a similar format, with test administrators showing children increasingly complex problems and asking them to provide an answer. Answers were untimed, each response was scored as correct or incorrect, and testing was discontinued when the child reached a ceiling. We converted the raw scores (i.e., sum of correct answers) of the two subtests to W scores, which is an item-response-theory based calculation provided by the Woodcock Johnson test that puts all responses on an equal scale and allows for comparison across time-points. For the current study, we used assessments collected in the fall semester (10/14 to 12/7) and spring semester (5/1 to 6/1) of preschool, and again in the fall semester (10/24 to 11/28) of the kindergarten year. See Table 2 for a summary of the children's performance on the WJ measures.

Preschool classroom friendship network

Friendship network was assessed using the traditional peer nomination approach (e.g., Parkhurst & Asher, 1992), which has been widely used in social network studies even among those conducted in preschool classrooms (Daniel, Santos, Fernandes, & Vaughn, 2019; McCandless & Marshall, 1957). In the present study, we asked children to nominate their friends via individual one-on-one interviews involving the focal child and a trained examiner in the spring of preschool year. A photo roster of all children in their classroom (not only those participating in the study, but the entire classroom roster) was presented to facilitate their nominations. [The governing human-subjects board allowed inclusion of all children on this roster, as omitting any child would divulge their status in the present study. This is the only manner in which non-consented children were included.] Children were allowed to nominate as many friends as they wanted, although they were encouraged not to nominate everyone in the classroom. If a child was selecting all their classmates, the assessor will present the child with the original prompt and reminded the child to "only pick a few classmates." On average, preschool children nominated two peers as friends (range 0–9 nominations; positively skewed). Interviews were conducted with an average of 84% of the students enrolled in any given classroom (range 60% ~ 100%).

An *n*-by-*n* friendship network matrix was created for each classroom; each cell in the matrix is a binary value representing whether or not a pair of children in the classroom mutually nominated each other as a friend. Based on the reciprocal friendship networks, two classroom-level indices were calculated: network *density* and network *centralization*. The network density score was calculated by dividing the number of observed mutual friendship ties by the maximum possible mutual friendship ties in the classroom. For instance, in a classroom with ten children, the maximum possible number of mutual friendship ties would be 10*(10−1)/2, which equals 45. If there were five pairs of children who mutually nominated each other as a friend, the network density score of this classroom is 5/45, which equals 0.11. The network density score theoretically ranges from zero to one, and the more connected the classroom friendship network is, the higher the network density score would be.

The network centralization score was the standardized sum of differences in individual centralities between the child with the highest centrality score and all other children in a classroom. Individual centrality is operationalized as the number of reciprocal friendship ties associated with each child in the network. The child who had the most friends is the one with the highest individual centrality score in the classroom. The network centralization scores theoretically range from zero to one. Classrooms with higher scores on centralization are those

that have more centralized friendship networks, where friendship ties or social power lie in a few individual children rather than being equally distributed among all children. The calculations of network densities and network centralizations were conducted in R with the *sna* package (Butts, 2016).

Preschool teachers' grouping preferences

Preschool teachers' grouping preferences were measured by a teacher-report instrument adapted from Gest and Rodkin (2011), in which teachers reported the importance of different strategies in assigning children in small groups. We implemented this instrument in the middle of the school year, with the assumption that teachers would have known a lot about their classrooms by then and thus have formed stable instructional strategies. We also assumed that teachers' instructional preferences stay relatively stable across the school year.

On this instrument, teachers first answered whether they let children work in small groups. In this sample 96% of teachers answered that they did let children work in small groups. On average, 35% of the classroom time was spent in small group activities ($SD = 23\%$, range = 0% ~ 90%). Teachers were then asked to rate how important the following considerations were when they assigned children to work in small groups: (1) to place students together who have different academic skill levels; (2) to place students together who have similar academic skill levels; (3) to place students together with others who are not yet their friends; (4) to place students together who are already friends; (5) to separate students who might pose behavior problems if they were in the same group; (6) to distribute students who might be leaders across groups; (7) to distribute students who might pose behavior problems; and (8) to accommodate students who might be shy or withdrawn. Teachers responded using a 3-point Likert scale with response options ranging from not at all important (= 0) to somewhat important (= 1) and very important (= 2).

We thus grouped the eight items into three subscales: academic-based grouping (items 1 and 2, Pearson's $r = 0.50$, $p < .001$), friendship-based grouping (items 3 and 4, $r = 0.32$, $p < .001$), and behavior-based grouping (items 5–8, $\alpha = 0.76$). Whereas the grouping of items was primarily based on theoretical reasons, we further examined the validity of the scale using confirmatory factor analyses (CFA) based on teacher-level data. We found that the eight-item, three-factor theoretical model fit our data reasonably well (Valid $N = 44$, Chi-squared = 11.984, df = 17, $p = .801$; RMSEA = 0.000, 90% CI = [0.000, 00.089]; CFI = 1.000).

Covariates

Covariates in the study included six child-specific variables: Child gender (1 = female, 0 = male), child age, child race (1 = white, 0 = other), child ethnicity (1 = Hispanic, 0 = non-Hispanic), child's DLL status (1 = DLL, 0 = non-DLL), and child's individual centrality in the classroom friendship network. In addition, mother's highest level of education was included (dummy-coded into two variables, High school diploma and Bachelor's degree or above). All of these data were obtained through parent report with the exception of individual centrality scores, which were derived from peer nomination data. We included five classroom-level covariates collected in preschool year: class size, age composition (pre-K only vs. other), program type (full-day five-day a week vs. other), teachers' years of experience teaching, and teachers' highest level of education obtained (bachelor's or higher vs. other). All five variables were obtained from teacher report. In addition, we also controlled for the variation in school districts, by adding district ID (1 = District 1, 0 = District 2) as a fixed covariate.

Analysis plan

The primary goal of the present study was to examine the extent to which the classroom friendship network and teachers' grouping preferences in preschool classrooms, two influencers of peer experiences, would be associated with children's growth in academic skills, particularly math and literacy development from preschool to kindergarten. A visualization of the conceptual framework guiding the analyses is shown in Fig. 1. Analyses were conducted using multilevel growth models (O'Connell, Logan, Pentimonti, & McCoach, 2013; Peugh & Heck, 2017), and the model for each academic outcome was fitted in two steps. First, unconditional three-level models were estimated, nesting time-points within children and children within classrooms, to determine the percentage of the observed variance that was attributable to differences between classrooms. Second, conditional multilevel models were fitted to the data, with the exact predictors and covariates documented above. For each outcome, we identified the extent to which between-classroom differences were explained after the inclusion of the predictors. All models were fit in Mplus 7.11 (Muthén & Muthén, 2012) with maximum likelihood estimation.

Missing data

Because multilevel growth models use all available observations to estimate growth trajectories from fall of preschool to fall of kindergarten, it can account for all longitudinal missing data in the outcome variables (i.e., WJ-AP and WJ-LWID) with maximum likelihood estimation. Missing data ranged from 0% to 9% for the classroom-level predictors and covariates, and were under 1% for child-level covariates. For missing data in predictors and covariates, instead of using listwise deletion, which has been shown to produce biased results and low power (Graham, 2012), we used full-information maximum likelihood (FIML; Arbuckle, Marcoulides, & Schumacker, 1996) to treat missing data. FIML assumes that data are missing at random (MAR), such that missingness is uncorrelated with unobserved variables. It is usually reasonable to assume MAR unless there are theoretical reasons to argue otherwise, and techniques such as FIML are robust to mild deviation from MAR (e.g., Collins, Schafer, & Kam, 2001; Schafer & Graham, 2002). Since we have no theoretical reason to suspect that the assumption of MAR was violated, FIML was deemed an appropriate method to handle missing data in the current study.

Results

Descriptive information and correlations

Table 1 displays the descriptive information of the key classroom-level variables, including teachers' grouping preferences and classroom friendship network indices. Teachers showed a significantly higher preference ($p < .001$ using repeated measures ANOVA) to behavior-based grouping (M = 1.69, $SD = 0.35$, range = 0–2) as compared to academic-based (M = 1.10, $SD = 0.55$) or friendship-based grouping (M = 0.99, $SD = 0.55$). Standardized peer social network density of reciprocal friendship was 0.07 ($SD = 0.05$), indicating that 7% of the children in a classroom had reciprocal friends. Network centralization averaged 0.11 ($SD = 0.05$) on a scale of zero to one.

Table 3 summarizes the correlations among classroom-level variables. Network density and centralization were positively correlated ($r = 0.64$). Classrooms serving only 4-year-old children (Pre-K classrooms), compared with mixed age classrooms, had lower scores for teachers' preference to academic-based grouping, as well as higher network density and centralization. Teachers with a bachelor's degree or higher, compared to their counterparts, tended to indicate higher preference to academic-based grouping, and lower preference to friendship-based grouping. Finally, classrooms from different counties were significantly different in the percentage of Pre-K classrooms, teachers' preference to academic-based grouping, and network density.

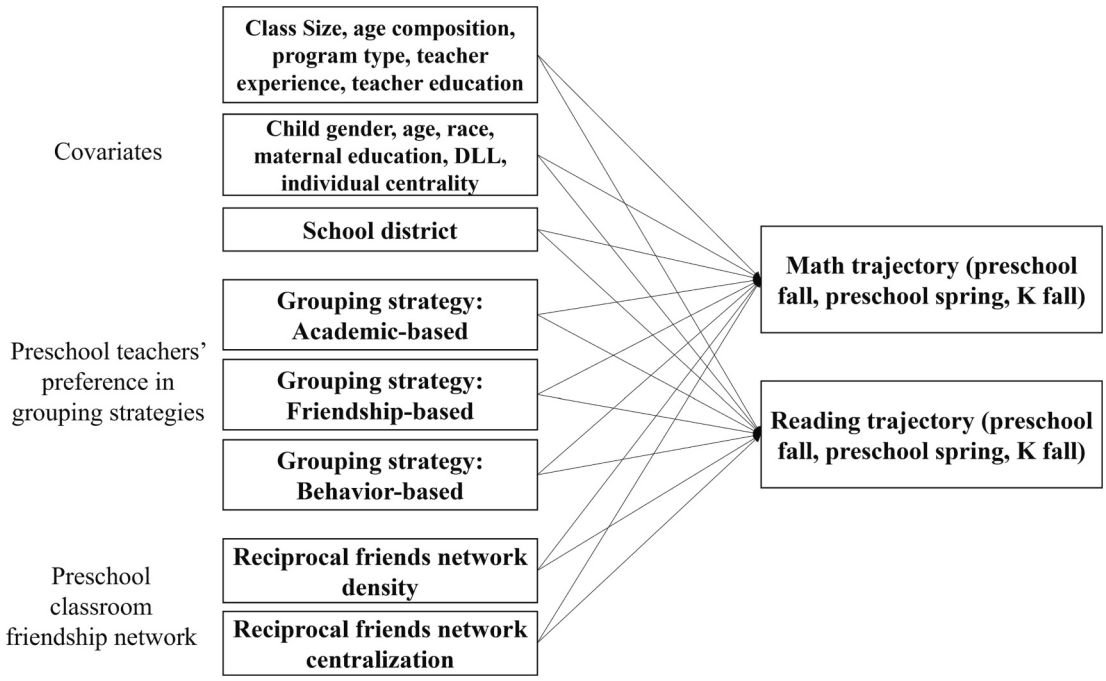

Fig. 1. Contribution of peer experiences to children's academic development: A visual depiction of the conceptual framework.

Table 3
Pearson correlations among classroom-level variables.

		1	2	3	4	5	6	7	8	9	10	11
	Teachers' Grouping Preferences											
1	Academic-based grouping	–										
2	Friendship-based grouping	−0.13	–									
3	Behavior-based grouping	0.13	0.23	–								
	Classroom Friendship Network[1]											
4	Network density	−0.19	0.07	−0.01	–							
5	Network centralization	0.02	0.10	0.18	0.64***	–						
	Covariates											
6	Class size	0.13	0.05	−0.14	−0.26	−0.19	–					
7	Pre-K classroom	−0.36*	0.06	−0.04	0.35*	0.29*	−0.07	–				
8	Full-time classroom	−0.12	−0.03	−0.01	−0.26	−0.05	0.07	−0.17	–			
9	Teacher experience	−0.24	−0.21	0.15	0.06	0.04	−0.12	0.18	−0.21	–		
10	Teacher bachelor's or higher	0.31*	−0.33*	−0.02	−0.23	−0.28	0.14	−0.25	−0.04	0.02	–	
11	District 1	0.36*	0.16	0.26	−0.39**	−0.24	0.08	−0.67***	0.23	0.03	0.08	–

* $p < .05$. ** $p < .01$. *** $p < .001$.
[1] Friendship network density and centralization were standardized by class size.

Multilevel growth models

Unconditional growth models

For math, the unconditional model showed that 36% of the variance was due to within-child change (time), 44% of the variance was due to differences between children, and 20% of the variance was due to differences between classrooms. These were similar to the percentages observed for literacy (43%, 39%, and 18%). The results of the unconditional model indicate that there is sufficient between-classroom variance for each child outcome of interest to warrant modeling or predicting between-classroom variability.

Conditional growth models

Table 4 summarized the parameter estimates for the conditional multilevel growth models. For each growth model, time was centered at the end of the preschool year, which corresponds to the middle (i.e., second) time-point of this investigation. When interpreting the results of these models, the first time coefficient (labeled *time fall PK*) corresponds to the estimates of children's scores at the beginning of the preschool year relative to the end of the preschool year; and the second coefficient (labeled *time fall K*) corresponds to the estimates of children's skills at the beginning of the kindergarten year relative to the end of preschool. Over the course of the study, children's math scores increased by 9.81 points from fall of preschool to spring of preschool, and by 14.63 points from spring of preschool to fall of kindergarten. Similarly, literacy scores increased by 16.03 points throughout the preschool year and then by 22.05 points from spring of preschool to fall of kindergarten.

For the conditional models, the first result to note is that for both the math and literacy outcomes, all of the between-classroom variation was explained after including the selected predictors (see R^2). In addition, covariates accounted for 8% ~ 10% of the variance between children, and time-points accounted for 42% ~ 58% of the variance within individuals over time.

Next, after accounting for all covariates, teachers' preference to friendship-based grouping and behavior-based grouping were not predictive of children's growth in math or literacy (Table 4; standardized estimates ranged from −0.02 to 0.06, all p-values > .05). However, teachers' preference to academic-based grouping was positively related

Table 4
Results of Growth Models.

	Math			Literacy		
	Est.	SE	Std. Est.	Est.	SE	Std. Est.
Level-1: Time ($N = 829$)						
Time Fall Pre	−9.81***	0.94	−0.35***	−16.03***	1.25	−0.42***
Time Fall K	14.63***	1.38	0.43***	22.05***	1.42	0.49***
Level-2: Children ($N = 367$)						
Friendship network individual centrality	3.27***	1.01	0.20***	2.71**	1.01	0.13**
Gender	−2.51	1.59	−0.08	−0.22	2.42	−0.01
Age	0.08	0.34	0.02	−0.06	0.28	−0.01
White	3.04	3.82	0.08	1.18	4.34	0.02
Hispanic	−3.89	4.26	−0.07	−10.28*	4.87	−0.16*
Dual language learner	−7.70*	3.65	−0.19*	6.84	4.33	0.13
Mom education: High school	−2.50	4.12	−0.07	2.04	3.67	0.04
Mom Education: College	0.87	4.18	0.03	6.44	4.59	0.15
Level-3: Classrooms ($N = 46$)						
Academic-based grouping	2.10*	0.82	0.18*	4.29***	1.26	0.22***
Friendship-based grouping	0.60	1.05	0.06	−0.06	1.37	−0.00
Behavior-based grouping	0.38	0.74	0.03	−0.34	1.21	−0.02
Friendship network density	7.88***	0.98	0.71***	11.18***	1.71	0.60***
Friendship network centralization	−3.88***	0.93	−0.35***	−7.74***	1.40	−0.42***
Class size	0.62***	0.17	0.20***	0.64***	0.19	0.13***
Serving pre-K age only	9.89***	2.61	0.44***	7.98*	3.55	0.21*
Full-time program	−0.19	2.03	−0.01	3.24	2.89	0.07
Teacher experience	0.02	0.09	0.02	−0.00	0.13	0.00
Teacher bachelor's or higher	−1.76	2.12	−0.07	−5.13	3.15	−0.12
District 1	−7.68**	2.61	−0.33**	−22.89***	3.04	−0.58***
R^2						
Level-1: Time	0.42***			0.58***		
Level-2: Children	0.10**			0.08		
Level-3: Classrooms	1.00***			1.00***		

Est. = Estimate. Std. Est. = Standardized estimate. SE = Standard error.
Note. Teachers' experience, grouping preferences, friendship network density, friendship network centralization and child's friendship network individual centrality are z-scored.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

to children's literacy gains (estimate = 4.29, standardized estimate = 0.22, $p < .001$) as well as math gains (estimate = 2.10, standardized estimate = 0.18, $p < .05$). With respect to the classroom friendship network, there was a significantly positive relation of classroom density with children's math gains (estimate = 7.88, standardized estimate = 0.71, $p < .001$) and literacy gains (estimate = 11.18, standardized estimate = 0.60, $p < .001$), but a significantly negative relation with classroom centralization (math: estimate = −3.88, standardized estimate = −0.35, $p < .001$; literacy: estimate = −7.74, standardized estimate = −0.42, $p < .001$) (Table 4).

To interpret these findings, with a one *SD* increase in teachers' preference to academic grouping, children's literacy scores are expected to increase by 4.29 points, or 0.22 *SD*, and children's math scores are expected to increase by 2.10 points, or 0.18 *SD*. With a one *SD* increase in the classroom friendship network density, math scores are expected to rise by 7.88 points or 0.71 *SD*, and literacy scores by 11.18 points or 0.60 *SD*. On the other hand, with a one *SD decrease* in friendship network centralization, math scores are expected to increase by 3.88 points or 0.35 *SD*, and literacy scores by 7.74 points or 0.42 *SD*.

Discussion

The purpose of this study was to examine young children's peer experiences in preschool settings for their potential contribution to development of academic skills specific to math and literacy. Math and literacy represent key indices of kindergarten readiness, and there is keen interest in ensuring that children enter kindergarten with well-developed math and literacy skills (Ansari & Winsler, 2016; Keys et al., 2013). Researchers studying kindergarten readiness emphasize the importance of identifying preschool classroom characteristics that are potentially influential to academic-skill development, and that these may represent important indicators of classroom or program quality. The present study contributes to this body of work by exploring peer experiences for their potential impact on math and literacy development, and is unique in its focus on the classroom friendship network and teachers' grouping preferences to represent the peer experiences. The findings of this work, as we discuss hereafter, considerably enhance our understanding of the specific aspects of children's peer experiences that contribute to math and literacy development.

The peer social network and academic development in preschool

The results of this study show that the classroom friendship network contributes to children's development in both math and literacy skills during preschool. Specifically, network density positively predicted children's math and literacy growth through the fall of kindergarten. Classrooms with denser friendship networks are those in which there is a high degree of cohesion or social bonding among children. There are several ways to interpret this result. One possibility is that in classrooms in which children are closely associated with one another in their friendship network, there is more harmony and positive peer collaboration and less conflict among children. This in turn serves to lower the amount of instructional time needed for behavioral management and allow teachers to spend more time on academic-oriented instruction. This draws upon a network diffusion perspective such that children in classrooms of higher friendship network density may have greater social connections, or social capital, to share their knowledge, beliefs and social behavior; this social process may help teachers and children to strengthen their adherence to positive social norms, such as academic behavior (McCormick & Cappella, 2015), which in turn foster children's learning in the classroom. An alternative possibility, based on the peer effects literature (e.g., Chen et al., 2020), is that denser classroom

networks better facilitate transmission of skills among children through their peer-to-peer interactions. In denser classroom networks, children have the opportunity to interact with peers and learn derive skills from these interactions, which would serve as a mechanism for math and literacy development. Regardless, the evidence provided in the present study indicates that denser classroom networks appear positively related to academic-skill development, which may signal the need to examine strategies to facilitate denser network formation in preschool classrooms. For instance, teacher-child managed whole-group instructions were found to positively benefit preschool children's academic gains in language and literacy skills during co-engagement in structured learning activities (Connor et al., 2006) as well as to promote preschoolers' social ties with both familiar and unfamiliar peers (Lin, Justice, Emery, Mashburn, & Pentimonti, 2017).

A separate index of the classroom friendship network, namely that of centralization, was also assessed in this study for its potential contribution to math and literacy development of young children. In highly centralized classrooms, friendship ties exist among a few children (i.e., sociometrically popular children) whereas the others are on the periphery of, or isolated from, the friendship network. Children within centralized, hierarchical classrooms therefore vary greatly in their social power and educational resources (Wasserman & Faust, 1994). In the present study, we observed a negative relationship between classroom centralization and children's math and literacy development during the preschool year, indicating that more centralized and hierarchical classrooms may compromise preschool children's academic development. From a network diffusion perspective, centralized networks may cause disruption to classroom communication and the power and resource imbalance may lead to negative social experiences and relationships (Serdiouk et al., 2015), which can impede children's learning. Additionally, in classrooms with more hierarchy, children may interact with fewer peers (i.e., only those in the same part of the overall network), which may reduce transmission of skills among peers. Taken together, these mechanisms may explain why children in more hierarchical classrooms demonstrated less academic growth than children in more egalitarian classrooms. This suggests that teachers may want to engage in classroom practices that reduce hierarchical structure in classrooms, such as equity practices in cooperative learning (Cohen, Lotan, Scarloss, & Arellano, 1999).

Teachers' grouping preferences

Teachers' grouping preferences in preschool settings, especially in conjunction with the friendship network in the classroom, have seldom been studied. In this study, however, we viewed teachers' grouping preferences as an important proxy of teachers' intentional grouping practices, which form a key aspect of children's peer experiences that may influence academic development. Interestingly, although teachers' reported practices specific to grouping based on friendships and behaviors were not associated with skill development, grouping practices based on academics were significantly associated with children's growth in literacy and math skills, which aligns with other preschool studies (e.g., Connor et al., 2006). It is important to highlight the potential value of teachers' use of grouping strategies in preschool settings as a way to enhance children's academic development, a practice often recommended within the Response to Intervention (RTI) literature. Specifically, in inaugural studies of RTI, teachers used smaller groupings of ability-grouped students to provide supplemental literacy instruction as early as kindergarten (Vellutino et al., 1996). Subsequent educational policy directions in the 2000s (Fuchs, Fuchs, & Zumeta, 2008) led to increases in teacher use of small-grouping structures in the early primary grades, and models soon emerged as to how RTI could be used within preschool settings (Buysse et al., 2016).

An important caveat must be drawn with respect to the present study, in that we did not query teachers as to how they used children's abilities to inform their grouping preferences; that is, we only asked whether teachers viewed it as important to consider children's abilities in grouping activities. The study findings indicate that children whose teachers viewed it important to consider children's ability levels in creating grouping structures experienced significantly greater math and literacy development over time than teachers who did not attend to children's abilities in their grouping preferences. The ambiguity around this finding – especially how teachers use ability to create groups in their classrooms – argues the need for more nuanced attention to preschool teachers' grouping strategies in preschool settings.

Implications for educational practices

In practice, our findings can help preschool teachers develop their group-based learning strategically within the context of their unique peer social network, to cultivate positive peer interactions and promote student learning. First, the findings suggest that teachers should be mindful of the social dynamics and ecology of the classroom, striving to cultivate dense and less centralized peer social networks. This can be facilitated by encouraging collaboration and positive peer interactions among all students, while specifically emphasizing the inclusion of children who may be marginalized within these networks. Second, the findings emphasize the importance of considering children's varying skill levels when forming small groups. By providing teachers with the knowledge and tools to create effective grouping, children's academic development can be better supported during the critical early school years.

This study also underscores the significance of peer experiences in assessing classroom quality. Early childhood education programs and policymakers may consider incorporating measures of peer social networks into classroom evaluations to better understand and support children's academic and socio-behavioral development.

Limitations and future directions

This study has several limitations of note. First, our study was situated in one regional area of a Midwest state, the teachers in our sample were well experienced, and the caregivers in our sample had a slightly higher education level than may be typical for the United States. As a result, it is unclear whether the findings presented here are generalizable. Second, our measure of teacher grouping preferences came from teacher report, and thus may not be a precise measure of teachers' *use* of different grouping strategies. Future studies using direct observation in addition to teacher report will provide a more accurate measurement of teachers' grouping practices. However, understanding why teachers group certain children together is an important aspect of grouping, and hard to capture through direct observations. Moreover, while in general the reliability and validity of the scales measuring teacher grouping preferences were acceptable, the lower correlation between the two friendship-based items ($r = 0.32$) suggested that further measurement work is needed to refine the scales. Third, we were only able to utilize children's peer nomination data from spring of the school year, because a large percentage ($> 60\%$) of peer nomination data in the fall were lost due to technical issues. Therefore, our measure of peer social network reflects the status of friendship network towards the end of the school year. Fourth, we were not able to examine potentially important interactions among study constructs due to constraints of the sample size. For instance, we did not look at the interplay between the friendship network and teachers' grouping preferences. Examination of such interdependencies will be an important future area of research on preschoolers' peer experiences. Fifth, with an effective sample size of 46 at the classroom level, our study may be underpowered to detect certain meaningful relationships between classroom-level predictors and outcomes.

Despite these limitations, this paper presents possible future research directions. First, this study's findings should be replicated in other contexts and with more diverse samples. Second, the use of teacher

report for grouping preferences could be augmented with direct observations of groupings practices to validate the present findings. Third, to better measure peer social network, peer nomination data should be collected at multiple time-points throughout the school year. Finally, replication studies with large classroom-level sample sizes are desirable. This would also allow researchers to explore interactions among peer-experience constructs, such as how the friendship network may be conditioned on teachers' grouping preferences. By addressing these and other questions, educational researchers will be able to better pinpoint aspects of peer experiences that influence children's math and literacy development. Despite these limitations, this study contributes to the growing body of work that highlights the social environment in the classroom as a key shaper of young children's academic development and points to specific malleable classroom features that can be improved through educational and policy practices in the future.

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Author statement

Informed consent was obtained for experimentation with human subjects.

Declaration of Competing Interest

None.

Data availability

The authors do not have permission to share data.

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