Early Education and Development

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

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To cite this article: Laura M. Justice, Hui Jiang, Jing Sun, Tzu-Jung Lin, Kelly Purtell, Arya Ansari & Nathan Helsabeck (2022): Classrooms are Complex Host Environments: An Integrative Theoretical Measurement Model of the Pre-K to Grade 3 Classroom Ecology, Early Education and Development, DOI: 10.1080/10409289.2022.2079321

To link to this article: https://doi.org/10.1080/10409289.2022.2079321

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Published online: 08 Jun 2022.

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EARLY EDUCATION AND DEVELOPMENT
https://doi.org/10.1080/10409289.2022.2079321

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Classrooms are Complex Host Environments: An Integrative Theoretical Measurement Model of the Pre-K to Grade 3 Classroom Ecology

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ABSTRACT

Research Findings: The purpose of this study was to test a theoretical measurement model representing four proposed dimensions of the classroom ecology in pre-K to third-grade classrooms. The four proposed dimensions of Classroom Composition, Peer Network and Norms, Teacher Practices, and Student Experiences were evaluated using data collected in 182 classrooms and 2,662 students in two districts spanning rural, suburban, and urban settings. Overall, the theoretical measurement model supported the multi-dimensional nature of the classroom ecology across the early primary grades, although specific characteristics and relations within the four dimensions may vary somewhat in pre-kindergarten settings compared to kindergarten through third grade. *Practice or Policy:* The overarching goal is to advance research that conceptualizes the classroom ecology more broadly to reflect both the academic and peer environment. The study is important for advancing understanding of salient characteristics of the classroom ecology that may foster learning and achievement.

Ecology, per dictionary.com, refers to the "set of relationships existing between organisms and their environment," and we use the term *classroom ecology* to represent the complex system of relationships among students and their teachers within the academically and socially oriented classroom environment. As with numerous other ecologies (e.g., wetlands, Simpson et al., 1983), we propose that the classroom ecology comprises *multiple distinct dimensions* that encompass varied aspects of the academic and social environments, a theoretical premise that we evaluate in this work. Specifically, we explored a theoretical measurement model reflecting the multi-dimensional classroom ecology, focused specifically on the early grades of schooling from pre-kindergarten (pre-K) to third grade (referred to as "P-3" hereafter), representing the P-3 continuum, and determine whether the theorized measurement model could be viable to represent all five years of schooling. To our knowledge, this study is the first to present an integrative theoretical measurement model of the P-3 classroom ecology, although it represents an extension of prior conceptual work that was foundational to the theoretical model (Bierman, 2011).

The present effort to evaluate an integrative theoretical model builds upon an extensive volume of empirical and conceptual work on P-3 classrooms. Regarding the former, this study in particular draws upon a strong research base showing that features of the classroom ecology exert a causally interpretable influence on children's development. For instance, children's academic development is modestly predicted by the quality of interactions taking place in their classrooms (Araujo et al., 2016),

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and their social skills are shaped by the behaviors of their peers (McGuire et al., 2015). Indeed, numerous studies describe the relations between discrete aspects of the classroom and children's outcomes in the early years, such as classroom composition (Justice et al., 2011), teachers' practices (Gest & Rodkin, 2011), and the social structure of the classroom (Ahn et al., 2010). In their aggregate, this body of work shows that many different aspects of the classroom matter for children's development, and also helps us to understand why some children thrive, and others do not, within the context of schooling (Justice et al., 2014; Mundy et al., 2017).

Many studies on the influences of the classroom ecology on child outcomes focus on one and oftentimes narrow element of the ecology. For instance, there are many studies of how the use of explicit teaching strategies affect content-area skill development (Brevik, 2019; See, et al., 2017), thus highlighting teacher practices for their salience. Other studies emphasize interactions within the peer social network as highly influential to social and academic development (Ahn et al., 2010; Gifford-Smith & Brownell, 2003), bringing attention to the role of children's classrooms in influencing their development. Of concern is that such efforts tend to work in parallel without capturing the additive and likely synergistic influences of both teacher practices and the peer social network on student outcomes. Given evidence that many disparate forces shape children's learning and development within the classroom ecology, classroom-focused research would advance if it incorporated multiple distinct dimensions; doing so would allow investigation of the unique and interactive influences of these dimensions on students. Indeed, without understanding the contingencies that exist within the classroom, our understanding of the classroom ecology and how it influences children's learning and development is incomplete.

To date, efforts to advance an integrative theoretical model of the classroom ecology and its presumably multiple and inter-related dimensions representing both the academic and social realm have been limited. Noteworthy, however, is a conceptual model put forth by Bierman (2011) which specified four distinct dimensions of the classroom: (1) Classroom Peer Ecology, (2) Classroom Teaching Ecology, (3) Child's Peer Experiences, and (4) Child's Teacher Experiences. Bierman suggested there to be significant interplay among these dimensions, in part to demonstrate the role of teachers in influencing the peer ecology. Although an important advance in the literature, Bierman's conceptual model has not been evaluated empirically. To further our understanding on the nature of potential dimensions of classroom ecology, we have two aims in the present study: (1) we propose an integrative measurement model to capture the breadth of the classroom ecology encompassing both individual and interactive experiences; (2) we empirically assess whether the proposed ecology model is viable to the P-3 continuum. The measurement model is built upon the conceptual model presented by Bierman (2011) as well as another by Gest and Rodkin (2011), by considering four distinct dimensions of the classroom, three representing classroom-level dimensions of *Classroom Composition, Peer Network and Norms*, and *Teacher Practices*, and one representing a child-level dimension of *Student Experiences*.

Dimension 1. Classroom Composition

Classroom Composition represents the way in which students are organized into classrooms as a function of gender, and such sociodemographic factors as age, ethnicity, race, linguistic background, and socioeconomic status. This dimension represents a set of classroom-level variables operationalized by both mean levels and variability for the classroom, often serving as a metric of "peer effects," or the effects of one's peers on his or her skills or behaviors (Sacerdote, 2011). Although the Bierman model (Bierman, 2011) did not include a classroom dimension specific to compositionality, there is increasing evidence that demonstrates that classroom composition is influential to children's development (Ansari et al., 2016) and thus should be included in theoretical models of the classroom ecology.

Theoretically, classroom composition captures objective attributes of the group with whom the child interacts, and there is considerable evidence showing that objective classroom compositional variables are important for young children's academic (Benner & Crosnoe, 2011; Henry & Rickman,

2007; Justice et al., 2014) and social-behavioral outcomes (Benner & Crosnoe, 2011; Gaviria & Raphael, 2001). For instance, Reid and Ready (2013) examined the relations between mean classroom socioeconomic status (SES) for 2,966 preschoolers in 704 classrooms and cognitive and social gains over the year the contribution of classroom; SES was positive and significant for measures of language and math, over and above the effects of a child's own SES. Such evidence shows that classroom composition may represent a salient dimension of the classroom ecology that influences children's development in P-3 settings.

Dimension 2. Peer Network and Norms

Peer Network and Norms represents the breadth, depth, and quality of peer affiliations among children within a classroom (Schaefer et al., 2010) as well as the norms attached to these affiliations (McGuire et al., 2015). Similar to Bierman's (2011) Classroom Peer Ecology dimension, the Peer Network and Norms dimension in our model represents a range of classroom-level variables often operationalized using social network analysis.

Peer networks are often characterized in terms of their level of *centralization* and *density*. *Centralization* represents the hierarchy of a peer network, with demonstrated linkages to children's social outcomes. Specifically, hierarchical classrooms may exacerbate children's aggressive and deviant behaviors (Ahn et al., 2010), potentially because these foster a social norm of competition and social dominance (Mikami et al., 2010). *Density* represents the degree of connectedness among children in a network. Children in a loose network are poorly connected with each other, whereas children in a dense network are highly inter-connected. If the social ties of a classroom network are highly associated with certain social values or behaviors, such as reading achievement or behavior problems – referred to as *norm salience* – a high-density network will accelerate children's acquisition of these values or behaviors, whereas a loose network can attenuate this acquisition. For instance, Ahn et al. (2010) showed that classroom density moderated the association between aggression and popularity: Aggressive children were more disliked and less popular in low-density classrooms.

We view Peer Network and Norms as a key dimension of classroom ecology based on theory and research suggesting that network structures provide contextual mechanisms that shape children's social interactions and relationships over time (Bramoullé et al., 2009), which in turn drive development (Bronfenbrenner & Morris, 2007). For instance, primary-grade pupils in small-group discussions will apply the reasoning strategies observed among their peers (Chen et al., 2020; Lin et al., 2012).

Dimension 3. Teacher Practices

Teacher Practices represents teachers' approaches to organizing and delivering instruction within the classroom, including both global and more proximal processes, which reflect their perceptions that transcend the classroom's academic and social milieu. This dimension resonates with Bierman's Classroom Teaching Ecology dimension. The role of teacher practices in facilitating children's learning within the classroom is well documented (Stipek et al., 2001; Viljaranta et al., 2015) with estimates showing that teacher effects on early reading and math achievement exceed that of school effects (Nye et al., 2004). There has been no determination to date as to which precise aspects of teachers' practices are most influential to children, but those that seem especially important include the amount of time they expose students to academic content (Ottmar et al., 2014), collaborative discussions (e.g., Lin et al., 2012), small-group instruction (Connor et al., 2014), delivery of quality instruction (Justice et al., 2008), and the attitudes and emotions they display toward children within the classroom (De Ruiter et al., 2019).

The importance of Teacher Practices dimension lies in the fact that teachers show substantial individual differences on all of the characteristics just referenced. For instance, global measures of the quality of teachers' interactions with their students show this to transcend the entire range of the scale utilized, with some teachers rated as very low in quality and others as very high (Fuligni et al., 2012).

Examination of more proximal indices of teacher practices show similar levels of variability (Connor et al., 2014). Importantly, individual differences among teachers in their practices are associated with children's development, as demonstrated in correlational (Ottmar et al., 2014) and causal studies (Connor et al., 2013; Rimm-Kaufman & Chiu, 2007).

Dimension 4. Student Experiences

Student Experiences represents individual children's experiences within the classroom environment, including children's interactions and relationships with peers. Children's peer relations are influential to both academic and social outcomes, the former because positive peer relationships can motivate students to engage in learning activities and provide them with opportunities to learn from another (Hughes & Kwok, 2006). For the latter, being accepted by one's peers is associated with satisfaction with school, perceived academic competence, and use of socially appropriate behaviors (Gifford-Smith & Brownell, 2003). The associations between peer relations and social competence is reciprocal: Children with secure relationships tend to have a history of successful socialization experiences that have taught them to regulate their emotions effectively when faced with new challenges (Wentzel & Watkins, 2002). We separated Peer Network and Norms from Student Experiences in our model to emphasize the distinction between classroom level and individual level from the ecological point of view.

To summarize, there is much to benefit from in advancing an integrative theoretical measurement model of P-3 classroom settings, as future work may seek to examine the interdependence among these dimensions when one or another is manipulated. For instance, consider the de-segregation of American schools in 1954, and the integration of children with disabilities into mainstream classrooms in 1975: both involved significant policy-specific interventions targeting the classroom composition dimension but likely had significant consequences for all other dimensions. For instance, as children with disabilities were integrated into general-education settings, teachers had to modify their teaching practices to support an increasingly diverse classroom of students (Bauwens et al., 1989), children with disabilities entered into classroom social networks and formed relations with typically developing peers (Chen et al., 2019), and the classroom experiences of children with disabilities were enhanced as they were exposed to more stimulating academic coverage (Hunt et al., 1994). As researchers continue to strive to improve the quality of classroom experiences for all children, including via experimental studies of the impacts of policy and practice modifications, it would be beneficial to consider impacts broadly across the integrative classroom ecology. Thus, to advance this aim, the present work was conducted to establish an initial integrative theoretical measurement model of the P-3 classroom ecology, building upon extant conceptual work articulating the multi-dimensional nature of classroom experiences in the primary grades (Bierman, 2011).

Method

Participants

Data were drawn from a federally funded project comprising three separate studies that were designed to improve understanding of children's learning experiences from pre-K to third grade. One study, the source for the current work, collected data from two cohorts of students in a cross-sectional design. Each cohort participated in the study for one academic year (2016–2017 and 2017–2018). In total, participants included 2,662 consented students in 182 classrooms from 43 schools in two large school districts in a Midwestern state. The two districts included urban, suburban, and rural settings and collectively served more than 40,000 students (pre-K to grade 12). Of the 2662 participating children from 182 classrooms, grade-specific representation was as follows: 582 Pre-K children from 47 classrooms (approximately 15 per classroom), 657 kindergartners from 47 classrooms (approximately

14 per classroom), 464 first graders from 28 classrooms (approximately 17 per classroom), 507 second graders from 31 classrooms (approximately 16 per classroom), and 452 third graders from 29 classrooms (approximately 16 per classroom).

The participating children from these classrooms (582 Pre-K, 657 kindergarten, 464 grade 1, 507 grade 2, 452 grade 3; 49% female) were diverse with respect to race as relative to the state population (66% White, 8% Black/African American, 6% Asian, 8% other and 12% multi-racial) and ethnicity (13% Hispanic/Latinx), with 12% of the students residing in households in which English was not the primary home language. Ten percent of the students had a disability, based on presence of an Individualized Education Program (IEP). Annual family income was distributed bimodally with 27% of the sample falling in the lowest income bracket (lower than $30,000 annual household income) and 34% of the sample in the highest income bracket (higher than $110,000) and the remaining 39% scattered in between. In addition, 45% of the students' mothers had at least a four-year college degree, with the remainder having an Associate degree or less.

With respect to teachers, most were female (97%), White (96%), and non-Hispanic (99%), with a mean age of 38 years and 13 years of teaching experience. Eighty-two percent of teachers had a teaching certificate, and 94% had a bachelor's or master's degree. An average classroom had 22 students (range = 12–29). Other sample demographics are reported in Table 1.

Procedure

Teachers and students participated in this study for one academic year, with the exception of a subset of pre-K and kindergarten students who were followed longitudinally to third grade. In accordance with protocols to protect human subjects as approved by the university's institutional review board, the research team first contacted schools within the participating school districts to recruit teachers by providing information about the study via discussion, presentation, and written materials. Consented teachers were asked to complete questionnaires about their classrooms, their students, and their own background as well as teaching practices. In addition, consented teachers agreed to allow for periodic observations in their classrooms.

All students attending classrooms with participating teachers were eligible to enroll. Consent packets were sent and returned via backpack mail. With parental consent, participating students completed direct assessments and child interviews, which included a peer-nomination task, administered by trained research staff. Children were also observed several times over the academic year. Consented parents completed a questionnaire at the beginning of the school year. Most participants were recruited in the fall although additional preschool classrooms were added later in winter and spring to meet recruitment goals in the first cohort of data collected.

Measures

To examine the dimensionality of the classroom ecology, measures were collected to represent the four theorized dimensions of Classroom Composition, Teacher Practices, Peer Network and Norms, and Student Experience. To fully capture these dimensions, nine measures providing data on 31 variables were administrated. Three dimensions were represented using variables collected or aggregated at the classroom level, whereas the Student Experience dimension variables were captured at the student level. In this section, we describe the measures used and the variables that contributed to different constructs and dimensions. Table 2 lists all indices used to describe the four dimensions along with their measures, scoring details, and internal consistency statistics (if applicable).

Classroom Composition

Seven variables represented classroom composition in this study: Gender diversity, racial diversity, ethnic diversity, language diversity, income diversity, maternal education diversity, and diversity for IEP. These variables were derived from questionnaires filled out by participating parents and teachers

Table 1. Description of the Analytical Sample (2662 students, 182 classrooms).

Variable	Valid *N*	% missing [a]	*M*/%	*SD*	Range
Student and family characteristics					
School district	2662	0			
District 1			61.9%		
District 2			38.1%		
Grade level	2662	0			
Pre-kindergarten			21.9%		
Kindergarten			24.7%		
First grade			17.4%		
Second grade			19.0%		
Third grade			17.0%		
Student age in fall (in months)	2646	0.6	78.18	18.37	25–124
Student gender	2652	0.4			
Male			50.6%		
Female			49.4%		
Student race	2626	1.4			
White			66.1%		
Black/African American			8.0%		
Asian			6.3%		
Other			7.9%		
Multiracial			11.8%		
Student Hispanic/Latinx	2633	1.1	12.7%		
Student has an IEP status	2450	8.0	10.1%		
Home language is English	2645	0.6	88.0%		
Annual household income	2560	3.8			
< $30,001			27.1%		
$30,001 – $50,000			12.2%		
$50,001 – $80,000			13.9%		
$80,001 – $110,000			12.9%		
> $110,000			33.9%		
Mother's highest level of education	2615	1.8			
Less than high school diploma			10.2%		
High school diploma or GED			31.8%		

(*Continued*)

Table 1. (Continued).

Variable	Valid *N*	% missing [a]	*M*/%	*SD*	Range
Associate degree			12.8%		
Bachelor's degree			24.8%		
Graduate or professional degree			20.3%		
Classroom and teacher characteristics					
School district	182	0			
District 1			64.3%		
District 2			35.7%		
Grade level	182	0			
Pre-kindergarten			25.8%		
Kindergarten			25.8%		
First grade			15.4%		
Second grade			17.0%		
Third grade			15.9%		
Teacher age (in years)	179	1.6	37.66	9.05	22–60
Teacher female	178	2.2	97.2%		
Teacher race	175	3.8			
White			96.0%		
Black/African American			2.3%		
Other and Multiracial			1.7%		
Teacher Hispanic/Latinx	174	4.4	1.1%		
Teacher certified	169	7.1	82.8%		
Teacher's highest level of education	174	4.4			
High school diploma or GED			1.1%		
Some college credit, no degree			2.3%		
Associate degree			2.3%		
Bachelor's degree			35.1%		
Master's degree			59.2%		
Teaching experience (in years)	173	4.9	13.39	8.15	2–36
Number of students in classroom	178	2.2	21.90	3.99	12–29
Percent of girls in classroom	176	3.3	48.75	8.59	17–71
Percent of White students	182	0	65.40	24.96	0–100
Percent of Hispanic/Latinx students	182	0	13.49	17.46	0–75
Percent of ELL students	177	2.7	19.13	25.02	0–100
Percent of students with an IEP	178	2.2	9.78	7.28	0–67

Note. Means are reported for continuous variables and percentages reported for categorical variables. Percentages may not sum to 100% due to rounding.
[a]% missing represents data that the participants did not report.

in the fall and winter of each school year to gather participating students' demographic information, which were used to calculate the classroom composition indices. The classroom composition variables were based on participating children in the classroom because teachers' report on classroom demographics was limited to gender composition and IEP status, whereas the whole class's race, ethnicity, and language were not available. In addition, only participating parents' income and maternal education information were available.

To construct our variables, we followed guidance from Benner and Yan's adapted version (Benner & Yan, 2015) of Simpson's Diversity Index to quantify categorical data at the classroom level. For example, the gender diversity index is a measure of heterogeneity of children's biological sex. With the two sexes (males and females), the lower the index (approaching zero), the more uniform the distribution of sex within the classroom (e.g., almost all students are males or all females); and the higher the index (approaching 0.5), the more evenly sex is distributed (e.g., 50% females and 50% males). For race, we used self-reported racial categories that were represented by more than 2% of the sample, which yielded the following categories: White, Black, Asian, other, and multiracial. For each classroom, proportions of each category were squared, summed across the categories, and then subtracted from one, with higher scores indicative of greater diversity. Similarly, for income diversity, we constructed a household income diversity index with five categories (<$30,000, $30,001–$50,000, $50,001–$80,000, $80,001–$110,000, >$110,000). Maternal education was also converted into the diversity index based on five categories (no high-school diploma, high-school diploma or General Education Development, Associate degree, bachelor's degree, and advanced or professional degree). The rest of the indices were created based on dichotomous variables, including gender, IEP status, ethnicity (Hispanic/non-Hispanic), and home language (English vs. another language).

Peer Network and Norms

Seven variables represented classroom network and norms. These variables were derived from two measures of Child Peer Nomination Rating scale (CPNR) that represent the classroom peer social network in terms of friendship density and centralization, as well as the norms associated with this network.

First, the peer social network in each classroom was measured by a peer-nomination task adapted from reports in the archival literature (e.g., Cillessen, 2009; Van den Berg et al., 2015). The peer-nomination task was conducted during a one-on-one interview with each student in quiet areas of the hallway by trained research staff. Presented with a chart that showed either his/her classmates' pictures (for pre-K and kindergarten students) or names (for students in grade 1, 2, and 3), each student was asked to select classmates that best fit the descriptions of each of six questions, including "In your classroom, who do you like to play with the most?" (*play most*) and "In your classroom, who are your best friends?" (*best friend*). The other four questions asked children to nominate those who get along well with other kids (*get along)*, they do not like to play with (*play least*), gets into fights with other kids (*fight)*, and are teased or picked on the most (*teased*). Although each student was able to nominate an unlimited number of classmates for each question, to ensure that students were thoughtful in their selections, assessors asked them to confirm their selections if more than five classmates were selected for a specific prompt.

The peer nomination data were used to calculate friendship-related indices for the Peer Network and Norms dimension. Specifically, when a student nominated a peer, the occurrence was labeled as a tie. Friendship density within the classroom was calculated as the total observed ties divided by the number of maximum possible ties, then standardized by classroom size. As such, the higher the friendship density value, the denser the classroom peer network. On the other hand, friendship centralization described the extent to which the cohesion of a classroom social network is organized around particular focal points. In this context, the focal points represent students who were most frequently nominated as best friends. Friendship centralization was calculated as the standardized sum

Table 2. Indices of Multi-dimensional Classroom Ecology Model.

Dimension	Variable/Indices	Measures	Scoring details	Reliability
Classroom Composition [a]	Gender diversity	Parent questionnaire	Categories: boys, girls; possible range = 0–0.5.	N/A
	Racial diversity		Categories: White, black, Asian, other, multiracial; possible range = 0–0.8.	N/A
	Ethnic diversity		Categories: Hispanic, non-Hispanic; possible range = 0–0.5.	N/A
	Language diversity		Categories: Students who primarily spoke English at home, students who primarily spoke another language at home; possible range = 0–0.5.	N/A
	Income diversity		Categories: household income <$30,000, $30,001–$50,000, $50,001–$80,000, $80,001–$110,000, > $110,000; possible range = 0–0.8.	N/A
	Maternal education diversity		Categories: no high school diploma; high school diploma/GED; Associate degree; bachelor's degree, graduate/professional degree; possible range = 0–0.8.	N/A
	IEP diversity	Teacher questionnaire	Categories: students with IEP, students without IEP; possible range = 0–0.5.	N/A
Peer Network and Norms	Friendship density	CPNR	"Who are your best friends?" peer nominations received by all students in the network, divided by the number of maximum possible ties, and standardized by network size. Possible range = 0–1; higher values = denser network.	N/A
	Friendship centralization		The extent to which the cohesion of a network is organized around particular focal points, based on "who are your best friends?" peer nominations. Standardized sum of differences in individual centrality (frequency of being nominated as "best friend") between the most focal child and all the other children in a classroom. Possible range = 0–1; higher value = more hierarchical.	N/A
	Reading norm salience	CPNR; WJ-III	Within-classroom correlation between WJ-III Letter Word ID (LW) score and number of "best friends" nominations received. Possible range = −1–1; higher value = higher social value placed on reading skills.	.98
	Math norm salience		Within-classroom correlation between WJ-III Applied Problems (AP) score and number of "best friends" nominations received. Possible range = −1–1; higher value = higher social value placed on math skills.	.94
Peer Network and Norms	Vocabulary norm salience		Within-classroom correlation between WJ-III Picture Vocabulary (PV) score and number of "best friends" nominations received. Possible range = −1–1; higher value = higher social value placed on vocabulary skills.	.85
	Task orientation norm salience	CPNR; TCRS	Within-classroom correlation between TCRS Task Orientation (TO) subscale score and number of "best friends" nominations received. Possible range = −1 – 1; higher value = higher social value placed on task orientation.	.94
	Behavioral control norm salience		Within-classroom correlation between TCRS Behavioral Control (BC) subscale score and number of "best friends" nominations received. Possible range = −1–1; higher value = higher social value placed on behavioral control.	.91
Teacher Practices	GS: Promote new friendship	TGS	Mean of two items: "To place students together with others who are not yet their friends" in the consideration of assigning (1) seating: (2) small groups.	.77
	GS: Reinforce existing friendship		Mean of two items: "To place students together who are already friends" in the consideration of assigning (1) seating; (2) small groups. 0 = Not at all important, 1 = Somewhat important, 2 = Very important.	.69

(*Continued*)

Table 2. (Continued).

Dimension	Variable/Indices	Measures	Scoring details	Reliability
	SD: mitigate status extremes	TSD	Mean of six items (e.g., I try to promote some degree of balance in social status across students in the classroom).	.80
	SD: support isolated students		Mean of four items (e.g., I try to help isolated or friendless students to develop friendships with specific classmates).	.77
	SD: manage aggressive behavior		Mean of five items (e.g., I try to structure the classroom to limit opportunities for aggressive, mean behavior).	.73
	SD: promote prosocial behavior		Mean of five items (e.g., I try to support students who are often the target of aggressive, mean behavior by creating positive social opportunities.) 0 = Never, 1 = Rarely, 2 = Sometime, 3 = Often, 4 = Very often.	.79
	Instructional support	CLASS	Mean of three dimensions (Concept development, Quality of feedback, and Language modeling). Possible range = 1–7.	.90
Teacher Practices	Emotional support		Mean of four dimensions (Positive climate, Negative climate, Teacher sensitivity, and Regard for student perspectives). Possible range = 1–7.	.76
	Classroom organization		Mean of three dimensions (Behavior management, Productivity, Instructional learning formats). Possible range = 1–7.	.74
	Percentage of teacher-led activity	C-SNAP	Leader domain, percentage of intervals coded as teacher-led activities, aggregated at the classroom level. 0–100%.	N/A
	Percentage of group activity		Grouping domain, sum of the percentages of intervals coded as large group, small group, or dyad, aggregated at the classroom level. 0–100%.	N/A
Student Experiences	Play most nominations	CPNR	Number of "who do you like to play with the most?" peer nominations received, standardized by network size. Possible range = 0–1.	N/A
	Best friend nominations		Number of "who are your best friends?" peer nominations received, standardized by network size. Possible range = 0–1.	N/A
	Get along nominations		Number of "who gets along well with other kids?" peer nominations received, standardized by network size. Possible range = 0–1.	N/A
	Play least nominations		Number of "who do you not like to play with?" peer nominations received, standardized by network size. Possible range = 0–1.	N/A
	Fight nominations		Number of "who gets into fights with other kids?" peer nominations received, standardized by network size. Possible range = 0–1.	N/A
	Teased nominations		Number of "who gets picked on or teased?" peer nominations received, standardized by network size. Possible range = 0–1.	N/A

Note. CPNR = Child Peer Nomination Rating Scale. WJ-III = Woodcock-Johnson III Tests of Achievement (Woodcock et al., 2007). TCRS = Teacher-Child Rating Scale (Perkins & Hightower, 2002). GS = Grouping Strategies. SD = Social Dynamics. TGS = Teacher Grouping Strategies (Gest & Rodkin, 2011). TSD = Teacher's social dynamics management strategies (Gest et al., 2014). CLASS = Classroom Assessment Scoring System (Pianta et al., 2008); C-SNAP = Classroom Snapshot.

[a]Reliability is measured by Cronbach's alpha.

of differences in individual centrality[1] between the most focal child and all the other children in a classroom. The higher the friendship centralization value, the more centralized the hierarchy of the social network.

Peer nomination scores show high levels of stability over time (Hughes et al., 2006), and are valid as long as 40% of students in a classroom are represented (Hughes & Cavell, 1999). For the present study, the peer-nomination task was given to all fully consented and passively consented students in each classroom, so that the data for each classroom encompassed roughly 83% of classmates (range: 58%–100%). The governing IRB and partnering school districts permitted use of passive-consent procedures as it involved only a brief task and no identifying information for the partially consented children.

The peer network data were also used to derive five norm salience variables, which describe the degree to which certain behaviors or performance are valued (i.e., salient) within the classroom social network. For the current study, we examined norm salience with respect to three academic areas, reading, math, and vocabulary skills, based on spring scores for each student on three subtests of the *Woodcock Johnson III Tests of Achievement* (WJ-III, Woodcock et al., 2007): Letter Word Identification (reading), Applied Problems (math), and Picture Vocabulary (vocabulary). Students were individually administered these subtests by trained research staff in private settings in their school over a four-week test window. For all three subtests, starting items varied according to students' grade level and the assessments followed basal and ceiling rules per the Examiner's Manual (Mather & Woodcock, 2001). For all subtests, responses were scored 1 as correct and 0 as incorrect, and then summed to create raw scores. When calculating the norm salience indices, we converted raw scores to standard scores, which were age-adjusted and represented the relative position of a student among his/her peers. Cronbach's alpha for the three subtests ranged from .85 to .98 for the current sample.

We also examined norm salience with respect to two social-behavioral areas, namely task orientation and behavioral control, based on spring scores for each student on the *Teacher-Child Rating Scale* (TCRS, Hightower et al., 1986). The TCRS is an indirect measure of children's problem behaviors and social competence and was completed in spring of the school year by teachers. Teachers rated children on statements using a 5-point Likert scale (*strongly disagree* = 0, *strongly agree* = 4) based on the extent to which the teacher agreed that the statements described the student. Each subscale contained eight items, four of which measured positive behaviors (e.g., this student is "a self-starter," "accepts imposed limits") and four negative behaviors (e.g., this student "has difficulty following directions," "disturbs others while they are working"). Negative items were reversed coded and scores were averaged for each subscale, with higher scores representing higher levels of social competency. Eight items were averaged to calculate a composite score for task orientation and behavioral control. Cronbach's α ranged from .90 to .91; test–retest reliability coefficient ranged from .64 to .90 (Hightower et al., 1986). Norm salience was calculated as the within-classroom correlation between students' academic or social-behavioral skills, and the extent to which the students were liked within the classroom network, as represented by the number of "best friend" nominations received.

Teacher Practices

Twelve variables represented teacher practices and fit into two categories: Teachers' use of strategies to influence socialization of students in the classroom via grouping strategies and social-dynamic management, and teachers' instructional practices.

Teachers' use of strategies to influence socialization of students in the classroom were captured using the Grouping Strategies (Gest & Rodkin, 2011) and Social Dynamics Management Strategies (Gest et al., 2014) surveys, which were completed in the spring of the school year. On the Grouping Strategies survey, teachers were asked to rate on a three-point Likert scale (e.g., *Not at all important* = 0, *Very important* = 2) the importance of (a) promoting new friendships and (b) reinforcing existing friendships when they created the classroom seating chart and assigned students to small groups for

purposes other than reading instruction. We averaged teachers' ratings across the two contexts (i.e., seating charts and small groups) to calculate the extent to which teachers viewed as important the promotion of new friendships versus reinforcement of existing friendships in grouping practices.

On the Social Dynamics Management Strategies survey, teachers reported on their use of various strategies to manage classroom dynamics related to social status, friendship, and aggression on a five-point Likert scale (e.g., *Never* = 0, *Very often* = 4). Teachers' ratings were averaged to create the following subscales: (a) mitigate status extremes (six items, alpha = .80), (b) support isolated students (four items, alpha = .77), (c) manage aggressive behaviors (five items, alpha = .73), and (d) promote prosocial behavior (five items, alpha = .79).

Next, teachers' instructional practices were represented by five variables derived from direct observations conducted in their classrooms using two tools: (a) Classroom Assessment Scoring System (CLASS; Pianta et al., 2008), and (b) Classroom Snapshot (C-SNAP). The CLASS is designed to assess the quality of instruction. Interactions between teachers and students were observed to code three domains of instructional quality: Instructional Support (i.e., concept development, quality of feedback, and language modeling), Emotional Support (i.e., positive climate, negative climate, teacher sensitivity, and regard for student perspectives), and Classroom Organization (i.e., behavior management, productivity, and instructional learning formats). Each domain is a composite score derived from ratings scored for specific dimensions, rated on a seven-point scale (*Minimally characteristic* = 1, *Highly characteristic* = 7). Reliability estimates for the three domains were $\alpha = 0.77$ (emotional support), $\alpha = 0.80$ (classroom organization), and $\alpha = 0.79$ (instructional support). CLASS coding was conducted during normal instructional hours between the fall and spring assessments, and consisted of two, 30-min observational cycles. We used scores for Instructional Support, Emotional Support, and Classroom Organization separately.

The C-SNAP is a live observational instrument that our team adapted from the Classroom Observation System (COS), as described in studies conducted by the NICHD Early Child Care Research Network (NICHD Early Child Care Research Network, 2002, 2005). In the present adaptation, C-SNAP observers coded the instructional experiences of four randomly selected students for two, 20-min cycles. Within a given 20-min cycle, each student was observed for 5 min and coded based on the activity he/she was engaged in during that five-minute span, in terms of skills targeted (e.g., language and literacy, math, arts), form of grouping (e.g., whole class, large group, small group, dyad, or individual), leader of the activity (e.g., teacher, student, or peer), and pedagogical methods used (e.g., direct instruction, discussion, and worksheet). C-SNAP observations occurred over two separate days. The percentage of time featuring teacher-led activities and the percentage of time spent in groups were aggregated at the classroom level to represent two variables specific to teacher practices.

Both CLASS and C-SNAP were coded live by trained reliable coders who had met criteria based on meeting reliability standards on five, gold-standard reliability videos. In addition, 20% of CLASS observations and 10% of C-SNAP observations were double-coded by the assigned coder and a master coder independently. Double-coding was higher for the CLASS because it is deemed a highly inferential tool, which can decrease inter-rater reliability across observers. By comparison, C-SNAP is less inferential in nature, with few inferences required to accurately code what children are experiencing (e.g., in a whole-group activity vs. working independently). For the CLASS, inter-rater reliability (computed using ICC) was .92 for cohort 1 and .90 for cohort 2. For C-SNAP, coders achieved 93% exact agreement for cohort 1 and 95% for cohort 2.

Student Experiences

Six variables represented the Student Experience dimension, each of which was derived from the peer-nomination task described previously. Calculated at the child-level, we calculated the number of peer nominations received for each of the six items ("play most," "best friend," "get along," "play least," "fight," and "teased"), standardized by classroom size.

Covariates

We explored the relationship between various factors of classroom ecology and five child outcomes assessed in the spring of the school year. Child outcomes included: (1) children's math and reading skills as measured by standard scores derived from two subtests of WJ-III (Woodcock et al., 2007), Letter Word Identification (reading) and Applied Problems (math); (2) children's socio-behavioral skills as rated by teachers using two subscales of the TCRS (Perkins & Hightower, 2002), behavioral control and peer social skill (averaged over eight items for each subscale); and (3) children's emotional outcome (i.e., how much they like or avoid school) as measured by nine items from the child-reported School Liking and Avoidance questionnaire with a Cronbach's alpha of .75 for the overall sample (Asher et al., 1984).

Analytical Approach

To address our research questions, we first examined descriptive statistics for all 31 variables comprising each of the four dimensions of classroom ecology (seven variables for Classroom Composition, 11 for Teacher Practices, seven for Peer Network and Norms, and six for Student Experiences), and estimated bivariate correlations among the indices within each dimension. Then, to validate (and revise as needed) the proposed theoretical structure of the classroom ecology, presented in Figure 1, we used confirmatory factor analyses at both the classroom level (comprising the dimensions of Classroom Composition, Peer Network and Norms, and Teacher Practices) and the student level (comprising the dimension of Student Experiences) using Mplus 7.11 (Muthén & Muthén, 2012) with maximum likelihood estimation. We evaluated model fit based on a variety of indices with recommended criteria (Hu & Bentler, 1999), including the chi-square test statistic (χ^2, cutoff criteria for a good fit is $p > .05$), Comparative Fit Index (CFI, a value of .95 or higher indicates a good fit), Tucker Lewis Index (TLI, a values of .95 or higher indicates a good fit), Root Mean Square Error of Approximation (RMSEA, a value smaller than .06 indicates a good fit) and Standardized Root Mean Square Residual (SRMR, a value close to .08 or lower represents a good fit). If model fit was unsatisfactory, modification indices were carefully examined to determine if there were cross-loadings or error covariances that would significantly improve model fit. Modifications were considered only if there was sufficient theoretical justification.

Once the factor structure of each dimension was validated, we conducted a series of multiple group confirmatory factor analyses to determine whether the factor structure was robust across grade groups (pre-K, kindergarten, and the three primary grades). We tested the invariance of factor loadings and covariances between factors across grade groups, and further analyzed the cases where invariance did not hold. In addition, as part of the exploratory study, we examined the potential correlations between the factors of classroom ecology and five child-level outcome variables (math, reading, behavioral control, peer social skill, and school liking). Specifically, the five child outcomes were added into the multiple-group factor models at the classroom level and at the child level, and allowed to covary with each factor.

Finally, even though there were no missing data for the student-level variables (i.e., peer nomination data), 1–4% of missing data existed for the classroom-level indices due to teacher non-response on certain items (see, Table 1, Table 3). To utilize all data available, we employed full information maximum likelihood (Arbuckle et al., 1996).

Results

Our proposed measurement model included 31 variables representing the integrative classroom ecology across four dimensions: Classroom Composition, Teacher Practices, Peer Network and Norms, and Student Experiences (Figure 1). Table 2 provides an overview of the 31 variables, and Table 3 summarizes descriptive statistics for these variables.

The sampled classrooms exhibited considerable heterogeneity with respect to the variables representing Classroom Composition, as shown by the range of scores for each of the seven variables (see details in Table 3). In terms of Peer Network and Norms, large between-classroom variation was observed in norm salience indices, in that the correlation between students' skills and their popularity among peers varied greatly by classroom (−.97 – .91), which was nearly the full range of possibility. The average norm salience indices were generally positive, although higher social values were placed on socio-behavioral skills (.26 – .32) than on academic skills (.06 – .13). The difference between behavioral and academic norm salience indices indicated that students' placed greater value (i.e., higher norms) on peers' social-behavioral competencies than their reading, math, and vocabulary skills.

As for Teacher Practices, teachers generally placed more emphasis on promoting new friendships in grouping arrangements than reinforcing existing friendships, and reported generally high and consistent use of strategies to manage social dynamics in the classroom. Scores on the CLASS showed that classrooms had higher scores in emotional support and classroom organization (5 out of 7 points) than in instructional support (3 out of 7). Additionally, on average, students spent 25% of the time on teacher-led activities and 32% of time in group activities.

Finally, at the student level, Student Experiences showed that an average student received positive nominations ("play most," "best friend," "get along") from 10% to 16% of his/her peers, and negative nominations ("play least," "fight," "teased") from 4% to 9% of his/her peers. The number of peer nominations received, however, differed greatly by student as evidenced by the large range of number of nominations. For instance, the "play least" nomination ranged from none to nearly all of their classmates.

Correlations Among Indices

Table 4 provides the correlations among all indices of classroom ecology by dimension. Overall, the clustering of correlated indices was consistent with our theoretical model. For example, within the dimension of Classroom Composition, gender, and IEP diversity were nominally correlated with the other indices; racial, ethnic, and language diversity indices were highly correlated (*r*s = .63–.72); and the indices measuring diversity in SES (i.e., income and maternal education diversity) were moderately correlated (r = .47). Similarly, correlations for the other dimensions generally met our expectations (Table 4).

Validating the Factor Structure of the Classroom Ecology Dimensions

At the classroom level, three dimensions were examined in our model: Classroom Composition, Peer Network and Norms, and Teacher Practices. The unmodified model had an acceptable fit as evaluated by the RMSEA (= .04) and SRMR (= .06), but the CFI (= .92) and TLI (= .91) values were not optimal. After carefully examining all suggested modifications, we added the following covariance term based on theoretical justification: Promote prosocial behavior and manage aggressive behavior. The resulting classroom-level model had an improved fit (χ^2 = 306.52, df = 245, p = .005; RMSEA = .04, 90% CI = [.02, .05]; SRMR = .05; CFI = .95; TLI = .93). At the student level, the unmodified model for the Student Experience dimension fit the data reasonably well (χ^2 = 158.73, df = 14, p < .001; RMSEA = .06, 90% CI = [.05, .07]; SRMR = .04; CFI = .96; TLI = .96). The standardized factor loadings for the final models are presented in Table 5. Magnitude of the standardized factor loadings ranged from .34 to 1.00 for the classroom-level model, and .33 to .97 for the child-level model.

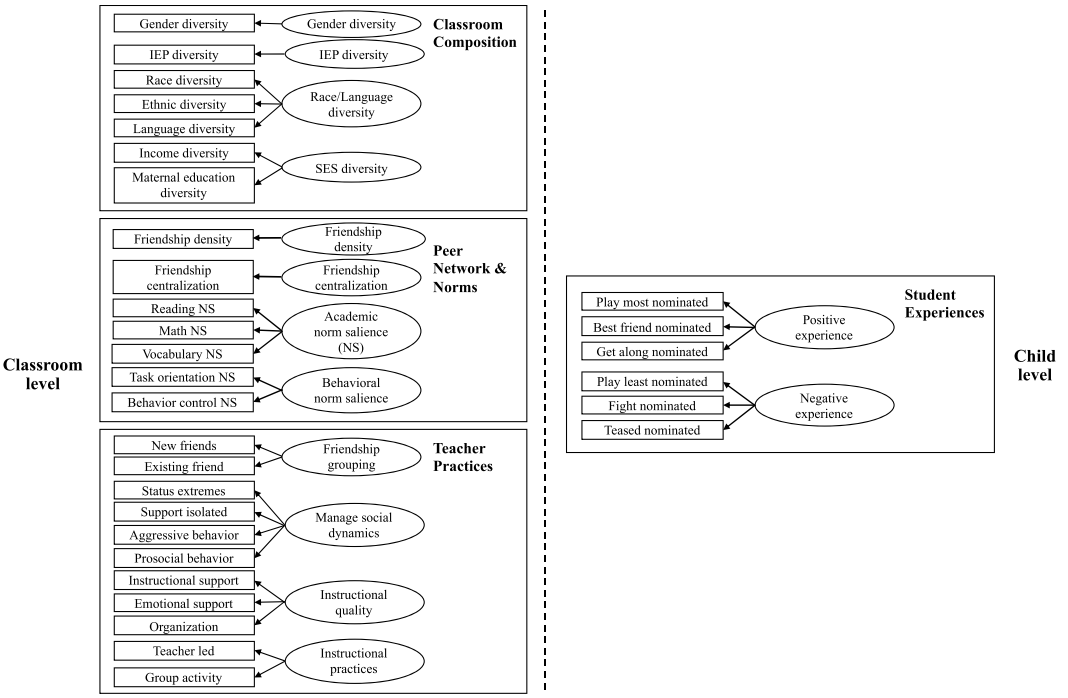

Figure 1. Conceptual Diagram of Multi-dimensional Classroom Ecology Model (Factor Covariances not Shown).

Testing Equivalence of Factor Structure across Grade Groups

Classroom-level Model

To examine the robustness of the empirically specified measurement model of P-3 classroom ecology, we used multiple group analyses to test the equivalence of the factor structures across the three grade groupings, namely pre-K, kindergarten, and primary grades (first grade, second grade, and third grade). We started with a baseline model where all factor loadings and covariances were held equal across grades, and compared its model fit with alternative models where the assumption of equivalence was relaxed. At the classroom level, factor loadings did not differ significantly across grades, as shown by the non-significant change in model fit when loadings were freely estimated for each group ($\Delta\chi^2$ = 15.70, Δdf = 41, p = 1.000). However, freeing the covariance estimates improved model fit ($\Delta\chi^2$ = 152.88, Δdf = 132, p = .103; ΔSRMR = −.02, ΔCFI = .02), indicating that at least some of the factor covariances differed significantly between grade groups.

To examine the factor covariances unique to grade groups, we first estimated factor correlations for each grade group based on the multiple group model with fixed factor loadings and free covariance terms (see, Table 6). Then, we formally tested for differential covariance terms using multiple group analyses. By relaxing each factor covariance in the model and comparing the model fit to the baseline model, we identified nine pairs of factors that have significantly different covariance terms across grade levels. For example, the association between SES diversity and academic norm salience was significantly different between primary-grade classrooms (Φ = .34, p < .05) and pre-K classrooms (Φ = −.04, n.s.). This implies that in primary grades alone, when forming social networks, classrooms with a more diverse SES composition tended to place heavier emphasis on academic skills as compared to classrooms that are less SES-diverse. Also unique to primary grades (and significantly different from pre-K and kindergarten), teachers' management of social dynamics and friendship-based grouping

Table 3. Descriptives of Indices in Multi-dimensional Classroom Ecology Model.

Dimension	Variable/Indices	*N*	% missing [a]	*M*	*SD*	Range
Classroom-level (*N* = 182)						
Classroom Composition	Gender diversity	176	3.8	.49	.03	.28–.50
	IEP diversity	178	2.7	.15	.14	.00–.50
	Racial diversity	182	0.5	.43	.22	.00–.77
	Ethnic diversity	182	0.5	.17	.17	.00–.50
	Language diversity	182	0.5	.13	.16	.00–.50
	Income diversity	182	0.5	.53	.20	.00–.80
	Maternal education diversity	182	0.5	.61	.10	.18–.78
Peer Network and Norms	Friendship density	181	1.1	.16	.05	.08–.60
	Friendship centralization	181	1.1	.16	.06	.06–.49
	Reading norm salience	179	2.2	.06	.31	−.74–.74
	Math norm salience	179	2.2	.13	.29	−.70–.80
	Vocabulary norm salience	179	2.2	.07	.27	−.61–.73
	Task orientation norm salience	176	3.8	.32	.29	−.81–.91
	Behavioral control norm salience	176	3.8	.26	.28	−.97–.80
Teacher Practices	GS: promote new friendship	176	3.8	1.11	.57	.00–2.00
	GS: reinforce existing friendship	176	3.8	.66	.50	.00–2.00
	SD: mitigate status extremes	180	1.6	3.14	.62	.67–4.00
	SD: support isolated students	180	1.6	2.98	.66	1.25–4.00
	SD: manage aggressive behavior	180	1.6	3.47	.44	2.20–4.00
	SD: promote prosocial behavior	180	1.6	3.32	.55	1.80–4.00
	Instructional support	179	2.2	3.08	.95	1.50–5.50
	Emotional support	179	2.2	5.28	.60	3.75–6.88
	Classroom organization	179	2.2	5.24	.67	2.83–6.50
	Percentage of teacher-led activity	179	2.2	25.55	12.30	0–57
	Percentage of group activity	179	2.2	32.43	22.59	0–94
Student-level (*N* = 2662)						
Student Experiences	Play most nominations (standardized)	2662	0	.12	.10	.00–.67
	Best friend nominations (standardized)	2662	0	.16	.12	.00–1.00
	Get along nominations (standardized)	2662	0	.10	.11	.00–.74
	Play least nominations (standardized)	2662	0	.09	.11	.00–.94
	Fight nominations (standardized)	2662	0	.07	.12	.00–.87
	Teased nominations (standardized)	2662	0	.04	.06	.00–.80

Note. GS = Grouping strategy; SD = Social dynamics.
[a]% missing represents data that the participants did not report.

practices were positively correlated ($\Phi = .52$, $p < .05$), indicating a more pronounced alignment of teachers' management of social dynamics and friendship-based grouping in primary grades compared to earlier grade levels.

In kindergarten alone, less gender-diverse kindergarten classrooms tended to have higher friendship centralization than classrooms with more balanced numbers of boys and girls ($\Phi = -.31$, $p < .05$), and this association was significantly different from those of pre-K ($\Phi = .12$, n.s.) and primary grades ($\Phi = -.05$, n.s.). Also for kindergarten classrooms only, behavioral norm salience was negatively related to teachers' management of social dynamics ($\Phi = -.58$, $p < .05$), but positively associated with friend network centralization ($\Phi = .29$, $p < .05$). This implies that in kindergarten, as students place higher social values on social-behavioral skills, the less teacher tended to adopt techniques to manage social dynamics, whereas the classroom network tended to become more hierarchical (instead of egalitarian).

Table 4. Pearson Correlation Coefficients Between Indices of Classroom Ecology by Dimension.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
Classroom Composition																	
1. Gender diversity	–																
2. IEP diversity	−0.1	–															
3. Racial diversity	.16*	−0.03	–														
4. Ethnic diversity	−0.07	−0.08	.63*	–													
5. Language diversity	0.02	−0.13	.68*	.72*	–												
6. Income diversity	0.11	.19*	−0.05	−0.14	−.20*	–											
7. Maternal education diversity	0.02	0.03	<.001	−0.03	−0.04	.47*	–										
Peer Network and Norms																	
8. Friendship density								–									
9. Friendship centralization								.43*	–								
10. Reading norm salience								0.05	0.04	–							
11. Math norm salience								−0.01	−0.01	.51*	–						
12. Vocabulary norm salience								0.02	0.07	.38*	.31*	–					
13. Task orientation norm salience								0.03	0.11	.32*	.34*	0.16	–				
14. Behavioral control norm salience								−0.01	0.05	0.08	0.14	−0.04	.66*	–			
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Teacher Practices																	
15. GS: promote new friendship	–																
16. GS: reinforce friendship	.35*	–															
17. SD: mitigate extremes	.13*	0.11	–														
18. SD: support isolates	.23*	.21*	.54*	–													
19. SD: manage aggressive	0.03	−0.04	.45*	.45*	–												
20. SD: promote prosocial	0.2	0.03	.36*	.45*	.65*	–											
21. Instructional support	−0.04	0.02	0.06	0.02	−0.05	<.001	–										
22. Emotional support	0.01	.15*	<.001	0.05	<.001	−0.01	.48*	–									
23. Classroom organization	−0.08	0.12	−0.06	0.02	0.03	0.04	.39*	.55*	–								
24. % teacher-led activity	−.16*	−0.08	0.06	<.001	0.04	−0.03	0.1	0.02	0.09	–							
25. % group activity	−0.11	0.08	−0.07	0.09	0.02	0.12	−0.14	0.03	−.15*	−.61*	–						
Student Experiences																	
26. Play most nominations												–					
27. Best friend nominations												.69*	–				

(*Continued*)

Table 4. (Continued).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
28. Get along nominations												.36*	.47*	–			
29. Play least nominations												−0.1	−.15*	−.17*	–		
30. Fight nominations												0.04	<.001	−.18*	.48*	–	
31. Teased nominations												−0.02	−0.06	−0.03	.31*	.19*	–

* $p < .05$.

Table 5. Factor Loadings of the Final Models for the Multi-dimensional Classroom Ecology Model.

Dimension	Factor	Variable	λ	*SE*	*p*
Classroom-level (*N* = 182)					
Classroom Composition	Gender diversity	Gender diversity	1.00		
	IEP diversity	IEP diversity	1.00		
	Race and language diversity	Racial diversity	.76	.07	<.001
		Ethnic diversity	.83	.07	<.001
		Language diversity	.87	.06	<.001
	SES diversity	Income diversity	1.00	.05	<.001
		Maternal education diversity	.46	.07	<.001
Peer Network and Norms	Friendship density	Friendship density	1.00		
	centralization	Friendship centralization	1.00		
	Academic norm salience	Reading norm salience	.79	.09	<.001
		Math norm salience	.65	.09	<.001
		Vocabulary norm salience	.47	.09	<.001
	Behavioral norm salience	Task orientation norm salience	1.00	.05	<.001
		Behavioral control norm salience	.66	.07	<.001
Teacher Practices	Friendship grouping	GS: promote new friendship	1.00	.05	.003
		GS: reinforce existing friendship	.34	.07	.009
	Manage social dynamics	SD: mitigate status extremes	.68	.08	<.001
		SD: support isolated students	.80	.08	<.001
		SD: manage aggressive behavior	.58	.08	<.001
		SD: promote prosocial behavior	.55	.08	<.001
	Instructional quality	Instructional support	.61	.08	<.001
		Emotional support	.80	.08	<.001
		Classroom organization	.69	.08	<.001
	Instructional practice	Percentage of teacher-led activity	1.00	.05	<.001
		Percentage of group activity	−.61	.07	<.001
Student-level (*N* = 2662)					
Student Experiences	Positive experience	Play most nominations	.74	.02	<.001
		Best friend nominations	.93	.02	<.001
		Get along nominations	.50	.02	<.001
	Negative experience	Play least nominations	.97	.05	<.001
		Fight nominations	.50	.03	<.001
		Teased nominations	.33	.02	<.001

Note. λ = Standardized factor loading; *SE* = standard error; GS = Grouping strategy; SD = Social dynamics.

Unique to the pre-K classrooms, instructional practice was positively related to friendship network density ($\Phi = .40$, $p < .05$), suggesting that classrooms with more intensive instruction tended to have more connected social networks. This was significantly different from what was observed in primary grades ($\Phi = -.13$, n.s.). Moreover, race and language diversity was negatively correlated with SES diversity in pre-K ($\Phi = -.37$, $p < .05$), which was significantly different in kindergarten ($\Phi = -.23$, n.s.) or primary grades ($\Phi = .13$, n.s.).

gTherefore, we conclude that while structural and measurement invariance generally held across grades for the classroom-level model, and that each factor represents a unique aspect of the classroom ecology, correlations between various factors could vary substantially by grade groups. The integrative model of classroom ecology also implied that different aspects of classroom ecology can be simultaneously incorporated in the same model with common

Table 6. Factor Correlations in Grade-specific Multi-dimensional Classroom Ecology Models: Classroom-Level.

Grade	Variables	1	2	3	4	5	6	7	8	9	10	11	12
Pre-K	1. Gender diversity	–											
(*n*= 47)	2. IEP diversity	−.36*	–										
	3. Race and language diversity	0.11	0.03	–									
	4. SES diversity	0.01	0.11	−.37*	–								
	5. Friendship density	0.16	−0.15	−.37*	0.2	–							
	6. Friendship centralization	0.12	0.09	−0.11	−0.11	.58*	–						
	7. Academic norm salience	0.1	−0.17	<.001	−0.04	0.25	0.09	–					
	8. Behavioral norm salience	−.30*	0.2	0.01	0.21	0.07	−0.12	.34*	–				
	9. Friendship grouping	0.02	−.39*	−0.26	0.01	0.09	0.05	−0.17	−0.27	–			
	10. Manage social dynamics	−0.01	0.15	0.01	−0.09	0.04	−0.02	0.18	−0.1	0.11	–		
	11. Instructional quality	−0.05	0.25	−0.04	<.001	0.26	0.17	0.18	−0.09	−0.19	0.01	–	
	12. Instructional practice	0.01	0.08	−0.01	−0.12	.40*	0.08	0.03	0.23	−0.19	−0.05	0.26	–
Kindergarten	1. Gender diversity	–											
(*n*= 47)	2. IEP diversity	−0.02	–										
	3. Race and language diversity	0.12	−0.11	–									
	4. SES diversity	−0.09	−.31*	−0.23	–								
	5. Friendship density	−0.15	−0.01	−0.19	0.19	–							
	6. Friendship centralization	−.31*	−0.12	0.14	0.16	.36*	–						
	7. Academic norm salience	−0.18	0.03	0.13	−0.18	−0.14	−0.11	–					
	8. Behavioral norm salience	0.08	0.05	0.28	−0.1	0.05	.29*	0.17	–				
	9. Friendship grouping	0.11	0.04	0.08	−0.18	0.07	0.19	0.15	0.04	–			
	10. Manage social dynamics	−0.26	0.13	0.08	0.01	−0.13	−0.13	−0.01	−.58*	0.04	–		
	11. Instructional quality	−0.21	.37*	−0.05	0.05	0.06	−0.03	0.17	−0.11	<.001	0.05	–	
	12. Instructional practice	0.11	−0.25	0.01	0.01	0.08	−0.05	<.001	−0.01	0.19	−0.14	−.30*	–
Primary grades, including first, second and third grades	1. Gender diversity	–											
(*n*= 88)	2. IEP diversity	−0.18	–										
	3. Race and language diversity	−0.11	−0.1	–									
	4. SES diversity	−0.01	.21*	0.13	–								
	5. Friendship density	<.001	−0.04	−.33*	0.03	–							
	6. Friendship centralization	−0.05	0.17	0.1	0.07	.39*	–						
	7. Academic norm salience	−.27*	.25*	0.16	.34*	0.08	0.22	–					
	8. Behavioral norm salience	−0.16	.21*	0.04	.24*	0.12	0.19	.56*	–				

(*Continued*)

Table 6. (Continued).

Grade	Variables	1	2	3	4	5	6	7	8	9	10	11	12
	9. Friendship grouping	0.06	−0.15	−0.2	−0.08	0.09	0.14	0.03	0.04	–			
	10. Manage social dynamics	−0.08	−0.06	−0.14	−0.22	−0.02	−0.14	−0.06	−0.07	.52*	–		
	11. Instructional quality	−0.01	0.01	0.02	−0.13	0.05	−0.05	<.001	−0.13	0.04	0.1	–	
	12. Instructional practice	0.18	<.001	0.09	−0.16	−0.13	0.01	0.01	−0.08	−0.14	0.06	0.06	–

* $p < .05$

variables and stable factor loadings across grades. Also of note is that the correlation estimates for the current study were obtained based on relatively small sample sizes (n = 47–88 classrooms for each grade group), and they should be interpreted with caution.

Student-level Model

At the student level, factor loadings were significantly different across grade groups ($\Delta\chi^2 = 72.60$, $\Delta df = 12$, $p < .001$), as was the factor covariance ($\Delta\chi^2 = 10.36$, $\Delta df = 2$, $p = .006$). Thus, we estimated separate models of the Student Experience dimension for each grade group (see, Table 7). Whereas the two-factor model fits the data from all three grade groups, the *loadings* of indicators varied. For instance, "fight" was the leading indicator in pre-K students' negative experience, whereas "play least" dominated the negative experience factor in the primary grades. "Teased" also increased in weight in higher grade levels in determining children's negative experiences (pre-K $\lambda = .20$, kindergarten $\lambda = .37$, primary grades $\lambda = .43$). Moreover, factors of positive and negative experiences were positively (albeit modestly) correlated in pre-K ($\Phi = .12$, $p < .05$), but negatively correlated in the primary grades ($\Phi = -.22$, $p < .05$). These results suggested that at the student level, the two investigated factors of classroom ecology might represent different underlying constructs in different grades, as measurement invariance was violated.

Exploring Correlation between Factors of Classroom Ecology and Child Outcomes

Upon examining the Pearson correlations coefficients between factors of classroom ecology and the five child outcomes (math, reading, behavioral control, peer social skill, and school liking), we found that the pattern of correlation was not consistent across grade groups at the classroom level (Table 8). For example, race and language diversity had a strong, negative correlation with aggregated math skills in pre-K ($\Phi = -.82$, $p < .05$), but this relationship was much attenuated in kindergarten ($\Phi = -.36$, n.s.) and primary grades ($\Phi = -.16$, n.s.). In another example, the correlation between friendship centralization and peer social skills was positive in kindergarten ($\Phi = .47$, $p < .05$), yet negative (small-sized albeit non-significant) in pre-K ($\Phi = -.23$, n.s.) and ignorable in primary grades ($\Phi = -.03$, n.s.).

Discussion

The conceptualization and measurement of the classroom ecology has long been a focal point of interest in the developmental and educational sciences. To date, however, few efforts have been made to advance an integrative theoretical model of the classroom ecology and its multiple and inter-related dimensions, and virtually no studies have considered these issues across the entire P-3 continuum. Accordingly, the present study extends our understanding of the dimensionality of children's classroom experiences during their earliest years of schooling by providing the first integrative measurement model of the classroom ecology, which is an initial step toward understanding the complementaries among these dimensions in how they influence children's learning. In so doing, this work serves to integrate parallel lines of research exploring academic (e.g., See et al., 2017) and social dimensions (e.g., Ahn et al., 2010) to achieve a broadened conceptual representation of P-3 classrooms.

An important catalyst for the present investigation is that many studies of children's classroom experiences focus on one dimension of the classroom without consideration of others. For instance, an extensive literature has studied classroom networks and their influence on children's social development (e.g., Ahn et al., 2010; Farmer et al., 2010; Gest & Rodkin, 2011), and such work has been utilized to design interventions that enhance children's classroom network experiences (Kamps et al., 2015). Yet, conceptually, many scholars would agree that the classroom ecology is multi-dimensional in nature and that dimensions may be inter-related.

Table 7. Factor Loadings and Model Fit Indices of Grade-Specific Multi-Dimensional Classroom Ecology Models: Student-Level.

Dimension	Factor	Variables	λ	*SE*	*p*	Model Fit Indices	Φ
Pre-K (n = 582)							
Student Experiences	Positive experience	Play most nominations	.77	.04	<.001	$\chi^2(14) = 29.34$, $p = .001$ RMSEA = .043 SRMR = .044 CFI = .975 TLI = .973	.12*
		Best friend nominations	.87	.04	<.001		
		Get along nominations	.43	.04	<.001		
	Negative experience	Play least nominations	.44	.03	<.001		
		Fight nominations	1.00	.00	<.001		
		Teased nominations	.20	.04	<.001		
Kindergarten (n = 657)							
Student Experiences	Positive experience	Play most nominations	.77	.03	<.001	$\chi^2(14) = 57.69$, $p < .001$ RMSEA = .069 SRMR = .059 CFI = .955 TLI = .952	−.10
		Best friend nominations	.91	.03	<.001		
		Get along nominations	.56	.03	<.001		
	Negative experience	Play least nominations	.67	.06	<.001		
		Fight nominations	.78	.06	<.001		
		Teased nominations	.37	.04	<.001		
Primary grades (n = 1423)							
Student Experiences	Positive experience	Play most nominations	.76	.02	<.001	$\chi^2(14) = 119.70$, $p < .001$ RMSEA = .073 SRMR = .049 CFI = .952 TLI = .949	−.22*
		Best friend nominations	.93	.02	<.001		
		Get along nominations	.53	.02	<.001		
	Negative experience	Play least nominations	1.00	.00	<.001		
		Fight nominations	.49	.02	<.001		
		Teased nominations	.43	.02	<.001		

Note. λ = Standardized factor loading; SE = standard error, Φ = inter-factor correlation
* $p < .05$.

By broadening conceptualization of the classroom ecology and its interconnectedness, our approach to designing educational interventions may be improved because any one feature of the classroom is likely to only modestly predict student outcomes (Ansari et al., 2016). Thus, by simultaneously testing multiple dimensions of the classroom ecology, we can idenfity each dimension's unique contributions to student outcomes, which in turn can inform educational practices. Admittedly, the present research is only a first step toward advancing the value of an integrative model of the classroom, as researchers must seek to understand how the varied dimensions uniquely and interactively affect children's academic and social development.

To that end, the first finding of this work is the establishment of an integrative measurement model of the classroom ecology, with overall model fit sufficient across the first five years of schooling. Bierman (2011) initially presented a conceptual integrative model of the classroom ecology, largely to argue that teacher-centric factors within the classroom likely have broader influence on children's peer experiences and subsequent classroom adaptation than is currently understood. Bierman conceptualized that the classroom teaching ecology (represented as Teacher Practices in the present work) had direct and indirect influence on the classroom peer ecology (Peer Network and Norms) and child peer experiences (Student Experiences) to shape child outcomes; in so doing, Bierman argued that a broader integrative conceptualization of the classroom is needed to strengthen educational practices, as doing so depends on understanding dimensions of the ecology most influential for students' development in the classroom context. Thus, an important contribution of the present investigation is the establishment of an integrative model of the P-3 classroom ecology that can be used to broaden conceptualization of how classroom experiences positively and negatively affect students.

The second finding concerns the theorized dimensions of the classroom ecology, and that its multidimensional structure transcends the first five years of schooling. Importantly, all dimensions included are malleable, and thus, can be affected by policies and practices to afford benefits to children. More

Table 8. Correlations between factors of classroom ecology and child outcomes by grade group (classroom-level, N = 182).

		Math	Reading			
Grade	Variables	(WJ-AP)	(WJ-LWID)	Behavioral control (TCRS)	Peer social skill (TCRS)	School liking
Pre-K (n = 47)	Gender diversity	0.16	−0.25	−0.06	0.2	<.001
	IEP diversity	0.2	−0.27	0.05	−0.08	−0.12
	Race and language diversity	−.82*	−0.03	−0.16	.23*	−0.09
	SES diversity	.39*	−0.25	0.2	−.33*	0.16
	Friendship density	−0.19	.58*	.37*	−.30*	0.19
	Friendship centralization	−0.01	0.1	0.14	−0.23	0.15
	Academic norm salience	−0.33	0.29	−0.23	0.28	.42*
	Behavioral norm salience	−0.18	0.28	−0.08	0.07	0.22
	Friendship grouping	0.04	−0.11	−0.25	0.09	0.26
	Manage social dynamics	0.2	−0.1	−0.05	0.25	−0.23
	Instructional quality	0.15	−0.29	0.4	−0.14	0.06
	Instructional practice	−0.18	0.28	0.15	−0.07	<.001
Kindergarten (n = 47)	Gender diversity	−0.02	−0.04	0.09	−.47*	0.03
	IEP diversity	−0.11	0.16	−0.27	0.02	−0.07
	Race and language diversity	−0.36	−0.25	−0.09	0.23	−.34*
	SES diversity	.40*	−0.09	0.01	−0.01	0.07
	Friendship density	0.24	−.27*	−.27*	0.22	−0.03
	Friendship centralization	−0.22	0.03	−0.13	.47*	−0.1
	Academic norm salience	−0.38	0.12	0.24	−0.11	−0.19
	Behavioral norm salience	−0.18	0.16	−0.03	<.001	−0.13
	Friendship grouping	0.16	−0.09	−0.09	−0.21	−0.04
	Manage social dynamics	0.19	−0.34	−0.07	.38*	−0.03
	Instructional quality	−0.25	.42*	−0.09	0.04	−0.1
	Instructional practice	0.08	−0.15	0.07	0.01	<.001

(*Continued*)

Table 8. (Continued).

Grade	Variables	Math (WJ-AP)	Reading (WJ-LWID)	Behavioral control (TCRS)	Peer social skill (TCRS)	School liking
Primary grades, including first, second and third grades (n = 88)	Gender diversity	.36*	−0.13	−0.05	−0.05	−0.08
	IEP diversity	0.07	−.38*	−0.1	−0.12	−0.02
	Race and language diversity	−0.16	−0.34	−0.06	0.23	−0.11
	SES diversity	−0.27	−0.21	0.05	0.09	0.04
	Friendship density	0.05	0.1	−0.13	0.03	0.17
	Friendship centralization	−0.06	−0.17	−0.02	−0.03	0.18
	Academic norm salience	−.43*	0.05	0.09	−0.08	0.21
	Behavioral norm salience	−0.23	0.03	−0.01	0.05	0.05
	Friendship grouping	0.14	<.001	−0.12	0.11	0.14
	Manage social dynamics	0.15	−0.11	−0.2	0.24	−0.2
	Instructional quality	0.21	0.02	0.11	−0.16	−0.08
	Instructional practice	0.2	−0.16	0.14	0.05	−.23*

Note. WJ = Woodcock-Johnson III Tests of Achievement (Woodcock et al., 2007); AP = Applied Problems subtest; LWID = Letter Word Identification subtest; TCRS = Teacher Child Rating Scale (Hightower et al., 1986).
* $p < .05$.

specifically, using a combination of teacher reports, classroom observations, and student assessments, we established a fourteen factor model that reflects the four key components of the classroom. First, Classroom Composition was represented by the ways in which students are nonrandomly organized into classrooms by virtue of age, gender, ethnicity, race, and disability. Considerable evidence points to compositional factors being influential to students' learning, both negatively and positively. For instance, being in a classroom comprised primarily of highly achieving peers is beneficial to the language growth of young children with disabilities (Justice et al., 2014) and being in classrooms with peers who are relatively high-SES benefits language and math development (Reid & Ready, 2013). Second, Peer Network and Norms was represented by the breadth, depth, and quality of peer affiliations among classmates and the norms attached to those affiliations. Evidence points to peer networks and norms as being influential to both academic and social skills (Gest & Rodkin, 2011), and that these can be experimented with to improve these outcomes (Kamps et al., 2015). Third, Teacher Practices, perhaps the most frequently studied ecological dimension in educational research (Araujo et al., 2016), represented teachers' approaches to delivering instruction within the classroom, including the quality their instruction and their approach used to group students. The fourth and final dimension, Student Experiences were captured by individual children's experiences in the classroom, in particular their positive and negative peer experiences. There are potentially other dimensions that warrant inclusion as integrative models of the classroom ecology are refined, particularly as attention to hybrid/distance learning technologies and racially just teaching practices amplify in classroom-based research. Yet, as an initial step to broadening conceptualization of the classroom experience, our model provides key insight into distinct aspects of the classroom that lay the groundwork for an examination of the links between children's classroom experiences and their academic and social development.

The third key finding stems from our test of measurement equivalence, which revealed that our multi-dimensional model of the classroom largely maintained internal reliability and conceptual coherence between pre-K and third grade. What this means, therefore, is that the theoretical model representing the classroom-level ecology can be measured reliably across grade groups and represents similar constructs across grades. Meanwhile, by formally testing differential covariance terms using multiple group analyses, our findings shed light on the characteristics of classroom ecology that are potentially distinct across grade levels. For instance, SES diversity and academic norm salience were positively associated in primary grades and significantly different from pre-K. This indicated that in primary grades, a less SES diverse classroom placed less emphasis on academic skills than a more diverse network. In our study, less SES diverse primary classrooms tended to be more socioeconomically advantaged. In particular, within the sample of primary-grade classrooms, classroom-aggregated income level and income diversity index were negatively correlated ($r = -.55$), so were the classroom-aggregated maternal education level and maternal education diversity index ($r = -.24$). Thus, it is reasonable for us to partially interpret this result in the context where academic skills were less emphasized in making friends by students with socioeconomical advantage, of which SES diversity serves as a proxy. In addition, our results showed that the association between gender diversity and friendship centralization in kindergarten was negative and significantly different from that of pre-K or primary grades. It is to note that gender diversity index indicated how evenly gender was distributed within the classrooms (see Measures). Thus, this association demonstrated a higher degree of gender homophily in kindergartners' social network (Fabes et al., 2003). Our interpretation on this grade-specific difference is that for kindergarten children, gender homogeneity tended to foster a more centralized social network, whereas in pre-K and primary grade levels, gender homogeneity effect might be balanced out by other factors such as higher intensity of academic demands and teacher management. Moreover, we found that teachers' management of social dynamics was negatively associated with behavioral norm salience in kindergarten, and that such an association was significantly attenuated in primary grades. It is to note that behavioral norm salience represents the popularity of the students who are equipped with better social-behavioral skills. Thus, in

a kindergarten classroom where children with higher social-behavioral skills are more popular, teachers' management of social dynamics was less implemented. In primary grades, on the other hand, this association might be adjusted by other factor such as academic demand and instructional practice.

As an exploratory study on classroom ecology, it is important to examine any potential correlations between factors both across and within dimensions. Any substantial factor correlations *across* dimension may indicate inter-correlated relationships or associations within the global ecological system surrounding students, and any substantial factor correlations *within* dimension (Φ's = .5–.6) may warrant the testing of a second-order model at different grade levels. These findings are meaningful for future exploration of contextual factors, such as the interaction between classroom diversity and teacher classroom management strategies (e.g., in managing social dynamics).

At the same time, however, our finding of comparability in classroom experience stands in contrast with students' individual experiences within classrooms. More specifically, although the same two-factor structure in the Student Experience dimension fit across grade groups, the factor loadings for negative (but not positive) experiences revealed some critical differences. In pre-K and kindergarten, negative experience was largely driven by "fight most" nominations, whereas for first through third grade negative experience was largely driven by "play least" nominations. Accordingly, these findings imply that students' positive experiences can be stably measured, whereas their negative experiences are changing in keys ways over time and driven by different indicators across different grade groups. Since we cannot assume that factors measuring children's individual peer experiences represent the same constructs across different grades, interpretation of the results at student level need to be taken with caution.

Lastly, we examined the correlations between the factors of classroom ecology and child outcomes. We found inconsistent patterns of these correlations across grade groups at the classroom level, which further suggest that whereas there was structural invariance of the classroom ecology model across grade groups, the relationships between specific dimensions and aspects of classroom ecology may need to be speculated on a grade-specific basis in future studies.

Despite these contributions to the literature, we also highlight several limitations of this work as well as potential areas of future investigation. First, the data on which this investigation was based were drawn from 182 classrooms in two large school districts in a Midwestern state. We cannot determine whether our findings would be generalizable to other areas of the country. In the future, it would be important that others researchers replicate (and extend) our model of the classroom ecology across different geographic locations. Likewise, although the current investigation presents a snapshot of the classroom ecology between pre-K and third grade, changes are likely to take place as children transition to the later years of school. Therefore, future research should also consider to what extent these dimensions of the classroom ecology remain similar (or change) across grade groups and developmental stages. In addition, although a clear strength of the present investigation is the use of classroom observations of teaching practices, similar to the extant literature (e.g., NICHD Early Child Care Research Network, 2002), our observations only capture a portion of children's time spent in the classroom. Given the above, future studies should consider the stability of observations across different times and days of the school year. Finally, and as noted earlier, a key issue for future research to pursue is an assessment of the associations between these different dimensions of the classroom ecology and their additive and synergistic associations with students' school success.

In summary, we conceptualized the classroom ecology as a multi-dimensional environment comprising Classroom Composition, Peer Network and Norms, Teacher Practices, and Student Experiences, and proposed a measurement model built on the theoretical account of the classroom ecology (e.g., Bierman, 2011). Using cross-sectional data of 2662 students from 182 pre-K to Grade 3 classrooms in two school districts, our data made clear that, even through the lens of a multi-dimensionality, the P-3 classroom ecology was fairly similar across grades with moderate grade-specific characteristics. Overall, the theoretical measurement model supported the multi-

dimensional nature of the classroom ecology across the early primary grades, although specific characteristics and relations within the four dimensions may vary somewhat among the three grade levels.

This study is important for advancing understanding of salient characteristics of the classroom ecology that may foster learning and achievement. By looking across dimensions of the classroom ecology, we provided key insight into the potential processes by which classrooms may shape children's academic and socioemotional development across grades. Furthermore, by bringing together a comprehensive model of classroom ecology, we broadened the conversation on how policy and practice changes may shape children's experiences in a classroom beyond the typical focus solely on academically focused instructional practices. As the research community continues to examine a more complete representation of classroom ecology, we can provide more nuanced insights to policymakers and practitioners and ultimately, improve the classroom experiences of young children.

Note

1. *Different from friendship centralization, individual friendship centrality represents the frequency at which a child was nominated by classmates as their best friend.*

Acknowledgments

We are grateful to the project staff, our district partners, and the children, families, and teachers who contributed data to this study. The investigators also express gratitude for Dr. Jessica Logan's intellectual engagement with the design, measurement, and analytical aspects of the larger study.

Disclosure Statement

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

Funding

This work was supported by the Institute of Education Sciences (IES) under grant [R305N160024] (PI Justice) and was conducted as part of the IES Early Learning Network.

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