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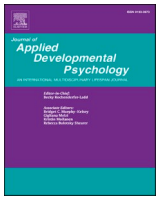

Differences between pre-k and kindergarten contexts and achievement across the kindergarten transition

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A B S T R A C T

Experiencing large differences between pre-k and kindergarten classroom contexts may affect children's academic development as they start school. This study examined differences between classroom contexts in pre-k and kindergarten (teacher-child interactions, time on academic content, and academic rigor) and associations with literacy, language, and math achievement in kindergarten fall and spring. 1498 children were followed from public pre-k through kindergarten (mean age = 52.8 months old at the start of pre-k, SD = 3.5). Children were ethnically and linguistically diverse (White = 7%, Black = 20%, Hispanic = 61%, Other = 12%; English at home = 21%, Spanish at home = 55%; other language at home = 24%). Piecewise growth modeling showed that experiencing a decrease in the quality of interactions or an increase in time on content or academic rigor was associated with lower than expected achievement in the fall of kindergarten but greater gains across the kindergarten year.

For years, investigators and practitioners in early education have raised concerns about the lack of continuity and alignment of children's educational experiences across grade levels, with a strong focus on continuity between pre-k and kindergarten viewed as a means to support children's transitions into formal schooling (Bogard & Takanishi, 2005; Scott-Little & Reid, 2010; Stipek, Franke, Clements, Farran, & Coburn, 2017). In theory, continuity between grades provides students with appropriate academic and social-emotional supports over time, fostering more efficient and effective development of early competencies in literacy and math (Stipek et al., 2017). In practice, very little research has examined the nature and extent of children's exposures to continuous or discontinuous experiences over time. Large, developmentally salient differences between educational contexts may be of particular concern for children who face early adversities associated with poverty, racism, or learning English as a second language, many of whom are served by public pre-k programs, precisely because instructional and relational supports in the classroom appear to be even more important for these children (Hamre & Pianta, 2005; McCartney, Dearing, Taylor, & Bub, 2007). The current work addresses the need for further empirical study of children's exposure to differences between pre-k and kindergarten contexts, using longitudinal data from a diverse cohort of public pre-k students that includes academic assessments and data on students' classroom experiences in pre-k and kindergarten.

Importance of continuity and alignment across pre-k and kindergarten

Evidence now strongly indicates that attending a formal preschool program (e.g., state pre-k, Head Start) is not likely to be enough, in itself, to fundamentally change the academic trajectories of children facing significant adversity (Bailey, Duncan, Cunha, Foorman, & Yeager, 2020; Bogard & Takanishi, 2005). Instead, practitioners and researchers argue that children benefit from connected, coherent, high-quality experiences across multiple years of schooling.

One idea arising from this perspective is that early learning experiences from pre-k through grade three should be aligned in support of children's development and provide some degree of consistency from year to year (Bogard & Takanishi, 2005; Reynolds, Magnuson, & Ou, 2010). At the highest level, there may be continuity across pre-k and elementary state learning standards, governance structures, student and family support services, and similar factors that are directly regulated through policy (Kagan, 2010). More proximal to children's daily experiences, and, arguably, more difficult to directly change through policy, are the pedagogical and relational practices that teachers employ every

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day in the classroom, such as how class time is used, how teachers and children interact with each other, and the academic rigor or challenge of the content presented to children (Kagan, 2010; Stipek et al., 2017).

It is hard to define what "continuity" means for these proximal daily experiences. Recent conceptual work argues that coherence and continuity across grades may involve increases or even decreases in certain classroom experiences, if those changes are aligned with children's developmental and learning needs (Stipek et al., 2017). For example, children who have mastered identifying letters of the alphabet in pre-k would be well-served by moving on to letter-sound correspondence and phoneme blending in kindergarten, an increase in the level of academic challenge. A class that presented these children with weeks of instruction on identifying letters, or that jumped directly to word reading, might not appropriately support their development as readers. Similarly, a child who attended a child-centered pre-k program with large amounts of unstructured time may benefit from a kindergarten classroom that includes high-quality instruction embedded within exploration and play, rather than a highly structured kindergarten classroom that spends most time in teacher-directed learning.

Why might experiencing sharp differences between pre-k and kindergarten contexts affect children's academic performance? There are several possible explanations. Research into sustaining environments suggests that some kindergarten experiences support retention of academic learning better than others, although evidence thus far is mixed (Bailey et al., 2020). For example, well-aligned content between grades may promote retention and reduce forgetting. Alternatively, performance may be lower post-transition due to context-based interference with retrieval, whereby children may have difficulty retrieving information from memory in a new context as opposed to a familiar context (Jonker, Seli, & MacLeod, 2013; Unsworth, Spillers, & Brewer, 2012); in which case the difficulty would be due to challenges to retrieval rather than actual learning loss or stagnation. Lastly, larger differences between contexts may cause children stress, which can hinder cognitive processing and working memory performance (Blair, 2010).

In prior work with the current data, we identified substantial differences between pre-k and kindergarten contexts that suggested misalignments or discontinuities that may be developmentally salient for children transitioning into kindergarten (Vitiello, Pianta, Whittaker, & Ruzek, 2020). It is not yet clear whether these types of differences between pre-k and kindergarten classroom contexts disrupt children's learning and development. It is not necessarily detrimental if, for example, differences between contexts mean that kindergarten provides better supports than pre-k, or if the differences are aligned with students' changing developmental needs. In keeping with this perspective, the current study is an exploratory effort to better understand and describe how differences between pre-k and kindergarten classroom experiences are associated with students' academic achievement. While there are many ways to empirically approach questions of alignment, continuity, and discontinuity, we start here by examining how the magnitude of the differences between contexts is associated with children's skills immediately upon kindergarten entry and across the kindergarten year.

Evidence of similarities and differences between pre-k and kindergarten

There is limited empirical work that examines pre-k and kindergarten classrooms and the differences or similarities between them. The analyses that do exist suggest that these settings tend to be substantially different from each other and may expose children to developmentally salient differences between academic environments (Abry, Taylor, Jimenez, Pratt, & LoCasale-Crouch, 2018; Franko, Zhang, & Hesbol, 2018). Examination of Head Start students' experiences upon starting kindergarten, which used the nationally representative FACES 2009 data set, indicated substantial structural differences between pre-k and kindergarten (larger class sizes, longer hours) but also found differences in the instructional emphases in literacy and math instruction (Abry et al., 2018). A separate cluster analysis of the FACES 2009 data found that 36% of children experienced a pattern of pre-k to kindergarten differences indicative of strong developmental appropriateness (e.g., increased focus on literacy and math and increased use of learning centers from pre-k to kindergarten; Franko et al., 2018). The remaining children experienced patterns indicative of less-optimal experiences from pre-k to kindergarten, such as poor alignment of instructional content or reduced focus on math and literacy in kindergarten.

Analyses of the educational environments of the pre-k and kindergarten classrooms in the current sample showed areas of potential discontinuity (Vitiello et al., 2020). Kindergarten classrooms had significantly lower observational ratings of the quality of teacher-child interactions compared with pre-k classrooms. Kindergarten classrooms also provided a sharp increase in structured learning time and time spent on literacy and math (Vitiello et al., 2020). Lastly, evidence suggested that kindergarten teachers, compared with pre-k teachers, endorsed teaching marginally more literacy and math concepts categorized as "basic" or on grade-level and substantially more concepts categorized as "advanced" (Vitiello et al., 2020). Thus, evidence suggests that children transitioning from public pre-k into kindergarten in the current study's sample experienced substantial differences in their educational environments across the transition from pre-k to kindergarten.

In this analysis, we focus on three key elements of pre-k and kindergarten contexts that empirical studies have shown to be associated with students' early academic development: the quality of teacher-child interactions (Burchinal, Vandergrift, Pianta, & Mashburn, 2010), the amount of classroom time dedicated to literacy and math instruction (Camilli, Vargas, Ryan, & Barnett, 2010), and the degree of academic challenge or rigor provided by the teacher (Claessens, Engel, & Curran, 2014). Although there is a large body of literature on teacher-child interactions that allows us to make directional hypotheses, we underscore that these analyses, and especially the analyses related to time on content and instructional rigor, are exploratory and intended to motivate additional research and theory in this area.

Differences in teacher-child interactions

Effective teacher-child interactions involve high levels of warmth and sensitivity on the part of teachers, active and sensitive management of children's time, attention, and behavior, and instruction that promotes higher-order thinking and language use (LoCasale-Crouch et al., 2007). In pre-k and the early elementary grades, teacher-child interactions are associated with students' gains in academic achievement, social skills, and self-regulation (Burchinal et al., 2010; Gosse, McGinty, Mashburn, Hoffman, & Pianta, 2014; Hamre & Pianta, 2005; Rimm-Kaufman, La Paro, Downer, & Pianta, 2005). Mounting evidence suggests two years of exposure to high-quality teacher-child interactions across pre-k and kindergarten have an additive positive effect on student outcomes (Cash, Ansari, Grimm, & Pianta, 2019; Vernon-Feagans, Mokrova, Carr, Garrett-Peters, & Burchinal, 2019). Based on this research, we expected that experiencing a decrease in the quality of teacher-child interactions as students transition from pre-k to kindergarten would fail to provide the developmental supports needed to sustain positive development of early academic skills like vocabulary, early literacy, and math.

Differences in instructional time

There is some disagreement among early childhood stakeholders who view self-directed play as fundamental to early learning (Nicolopoulou, McDowell, & Brockmeyer, 2006) and those who argue that children need substantial time on academic content in order to reach their potential (Fuller, Bein, Bridges, Kim, & Rabe-Hesketh, 2017). Emergent evidence does suggest that more academic time is associated

with better academic outcomes (Fuller et al., 2017) and yet there is no empirical evidence to determine how much time on academic instruction is enough or too much in pre-k or kindergarten. We speculate that an increase in instructional time may be developmentally appropriate, insofar as it suggests less academic focus during pre-k and more academic focus in kindergarten. However, we also note that structured learning time can be associated with decreased student engagement in learning and therefore may have the unintended effect of undermining children's self-regulation and motivation and, thus, achievement (Barker et al., 2014; Ryan & Deci, 2000; Vitiello, Booren, Downer, & Williford, 2012).

Differences in academic rigor or challenge

Academic rigor refers to the degree to which instruction covers advanced topics that push children's knowledge and understanding. An emerging body of research suggests that teachers tend to misestimate what children know and can do (Jamil, Larsen, & Hamre, 2018) and may provide inappropriate levels of instructional challenge as a result (Engel, Claessens, Watts, & Farkas, 2016). Nationally representative data suggest that many children who are academically well-prepared for kindergarten experience instruction below their capacities during the kindergarten year (Engel, Claessens, & Finch, 2013) despite research indicating that children across skill levels benefit from exposure to more advanced content (Engel et al., 2016; Le, Schaack, Neishi, Hernandez, & Blank, 2019). Experiencing an increase in academic rigor may therefore be expected to support children's academic development in positive ways; although it is also possible that substantial increases in rigor are stressful for children and disrupt learning.

The current study

To our knowledge, there has not yet been an empirical analysis examining whether and how differences that children experience between pre-k and kindergarten are associated with students' academic performance in kindergarten. We recognize that some differences between pre-k and kindergarten may actually be developmentally appropriate and supportive of ongoing development, such as when students transition into a classroom that provides higher quality teacher-child interactions, or when increases in instructional time or rigor support students' learning. This study seeks to provide an empirical basis for further research and theory development by exploring whether and how differences between educational environments are associated with children's academic performance upon kindergarten entry and gains from fall to spring in kindergarten.

We hypothesized that experiencing an increase in the quality of teacher-child interactions from pre-k to kindergarten would be associated with better academic achievement (higher skill levels in the fall and greater gains across the year) in kindergarten. For time on content and academic rigor, we refrained from making directional hypotheses as the prior evidence is not sufficient.

Method

Recruitment and participants

This study was reviewed and approved by the authors' institutional review board. Data for this study come from a large longitudinal study of children who attended public pre-k in a large, culturally and linguistically diverse school system. Teachers were recruited in the fall of 2016 from publicly funded center-based classrooms that served children from low-income families. A total of 138 pre-k classrooms were eligible to participate in the project based on child enrollment (classrooms had to have five or more publicly funded children eligible for kindergarten the following year), of which 117 consented to participate in classroom observations and were included in the current analysis. Participating teachers sent home consent forms and family demographic surveys to eligible children. Children were eligible for the study if they turned four by September 30 and did not have an Individualized Education Program (IEP) other than for speech. Eighty percent of parents had children who were eligible to participate and consented to allow their child's participation, resulting in 1498 participating children. Participating children were followed annually from pre-k through third grade.

At the start of pre-k, children were 52.8 months old (about 4.4 years) and had parents with a high school degree on average. The sample was racially and ethnically diverse, with 20% Black, 61% Hispanic, 7% White, and 12% other ethnicity or multi-racial. Fifty-five percent of children spoke Spanish, and 24% of children spoke another non-English language at home.

Income-to-needs ratios are the ratio between household income and the federal poverty guideline, adjusted for household size. Ratios greater than one indicate that family income is above the poverty guideline, and ratios below one indicate that family income is below the poverty guideline. On average, families in our sample were living below the federal poverty guideline ($M = 0.86$, $SD = 0.53$), which was $24,300 for a four-person family in 2016 (Annual Update of the HHS Poverty Guidelines, 2016). Additional demographic information about children is presented in Table 1.

In terms of attrition from pre-k to kindergarten, we were able to locate 90% of the child sample, spread across 404 kindergarten classrooms. Of these, 289 teachers consented to participate fully in the study and are included in the current analysis. Pre-k teachers had 17 years of education and 16 years of teaching experience on average; in kindergarten these figures were 18 and 7, respectively. Classrooms in pre-k and kindergarten were balanced in terms of the proportion of boys and girls (50–51% boys) and those identified as limited English proficient (52–63%) and included a small proportion of students with special needs (7–8%). Forty-eight percent of pre-k teachers spoke Spanish, whereas in kindergarten 28% of teachers spoke Spanish.

Measures and procedures

Parents completed a demographic survey about themselves and their children (ethnicity, home language, family income, children and adults in the home) when they consented for their child to participate in the study. Schools provided additional information on home language as well as each child's age and gender. In the fall of pre-k and kindergarten, teachers completed questionnaires that included teacher and classroom demographic information. In the spring, teachers completed another survey about teaching practices and characteristics of the class. Pre-k teachers were compensated $75 in the fall and again in the spring for completing surveys and child rating scales ($150 total). Pre-k and kindergarten teachers gave us feedback that they did not want to provide social security numbers to the university, which was required by university policy if compensation was greater than $50 in a calendar year. Therefore, we compensated kindergarten teachers $50 in the fall

Table 1
Descriptive statistics for the study sample.

	Mean (SD) or Percent	*n*
Age at beginning of pre-k	52.82 (3.49)	1301
Male	50%	1487
Race/ethnicity		
White	7%	1465
Black	20%	1465
Hispanic	61%	1465
Other	12%	1465
Home language		
English	21%	1484
Spanish	55%	1484
Other	24%	1484
Income-to-needs ratio	0.86 (0.53)	1168
Switched schools from pre-k to K	27%	1498

and spring ($100 total). Children were given stickers to thank them for their participation in direct assessments.

Classroom environment indicators

The quality of teacher-child interactions was observed by trained coders using the Classroom Assessment Scoring System (CLASS; Pianta, La Paro, & Hamre, 2008) which captures sensitive, supportive, and stimulating interactions between teachers and children across three broad domains (Emotional Support, Classroom Organization, and Instructional Support. The 10 CLASS dimensions associated with these domains are coded on a seven-point scale with detailed behavioral descriptors of interactions at the low (1–2), mid (3–5), and high (6–7) ranges of effectiveness. Coders completed a 2-day training, which involved learning about the measure and then coding classroom video segments with increasing independence. Following the training, coders were required to take and pass a reliability test that involved coding five videos with 80% of codes within one point of the master codes.

Classrooms were observed and coded in multiple, 25-min cycles over the course of 2–3 days, which included 15 min to observe and record classroom interactions and 10 min to code the 10 CLASS dimensions (Pianta et al., 2008). In pre-k, observers alternated between CLASS observation cycles and cycles of a child observation measure throughout the day; in kindergarten, observers conducted CLASS observation cycles continuously. In both grades, all activities were observed and coded except for nap time, outdoor recess, lunch in a cafeteria, and activities taught by a different teacher in a separate classroom (i.e., "specials"). Double-coded observations indicated strong agreement between coders (intraclass correlations (ICCs) = 0.73 in pre-k, 0.69 in kindergarten). The CLASS domains were collapsed into one total classroom quality score because of the high correlations between the individual domain scores. Previous research has indicated that compositing the scores is acceptable (Vitiello, Bassok, Hamre, Player, & Williford, 2018).

The amount of time on academic content was observed using the Classroom Snapshot during CLASS observation cycles. The Classroom Snapshot captures classroom-level activities and content of instruction during CLASS observation cycles. Content is recorded using a continuous timing feature within the coding application: coders select content codes from a preset list at the start of each observation cycle and change them as the content changes. The list includes language; literacy; math; science; social studies; social-emotional content; art, music, and dance; various (coded when children are in multiple different activities, such as during free play/choice time); and other. Language and literacy codes were collapsed to form a single language & literacy code for the current analyses. Codes represent the proportion of each 15-min observation cycle that was dedicated to each content area and were averaged across observation cycles to arrive at classroom averages. Data collectors were trained on the Classroom Snapshot in a two-hour block during the CLASS observation training. Intraclass correlations from double-coded observations in the field indicated acceptable agreement between coders (ICCs for math, = 0.68 in pre-k, 0.93 in kindergarten; for language & literacy, 0.59 in pre-k, 0.87 in kindergarten).

Pre-k classrooms were observed from November through March, with at least one observation in the fall and one in the spring. Kindergarten classrooms were also observed from November through March, but with observations spaced within two weeks of each other to reduce teacher burden, in response to teacher feedback. There was no significant correlation between observation date and CLASS score in the kindergarten data.

To measure academic rigor, teachers responded to a series of items on language/literacy and math instructional content. In pre-k, the survey was sent in March and we received responses through May. In kindergarten, the survey was sent in April and we received responses through June. Items were adapted from the Early Childhood Longitudinal Study – Kindergarten: 2011 Cohort (ECLS-K:2011) teacher questionnaires (Westat, 2013) following procedures similar to those used by Claessens et al. (2014). Literacy and math items were selected to represent a range of difficulty levels and content areas and were edited for clarity and to increase alignment to state standards and learning trajectories. The pre-k survey included 29 literacy items and 26 math items, including 22 literacy linking items (i.e., items that appeared on another form and therefore linked the two forms together) and 14 math linking items; the kindergarten version included 35 literacy items (including 20 linking items) and 34 math items (29 linking items) because additional, more difficult items were added to better cover a full range of instructional rigor in kindergarten. For each item, teachers indicated whether the content was taught as part of general classroom instruction, taught only to struggling or advanced students, or not taught because it was too easy or too hard.

To score the data, we recoded each item as "taught as part of general classroom instruction" or not and scored the items using a Rasch model in JMetrik (Meyer, 2014) to create separate instructional rigor scores for math and literacy. Rasch analyses were based on data from 868 teachers: 117 pre-k teachers, 349 kindergarten teachers, and 402 first grade teachers. (First grade teachers' data is not otherwise included in the current study. The first grade survey included 33 literacy items and 32 math items, all of which had appeared on prior forms.) The initial analyses included a total of 49 literacy items and 52 math items. After removing items with poor infit (values below 0.5 and greater than 1.5; Meyer, 2014), literacy scores (thetas) were estimated from 45 items. Item reliability was strong (0.98) and person reliability was acceptable (0.75). Math thetas were estimated from 51 items and showed strong item (0.99) and person (0.88) reliabilities. Higher thetas indicate that the teacher provided more rigorous or challenging instruction.

Child outcome measures

Children's language, literacy and math achievement were assessed with four subtests from the Woodcock Johnson III Psychoeducational Battery (WJ-III; Woodcock, McGrew, & Mather, 2001). Children's literacy skills were assessed with the Letter-Word Identification subtest of the WJ-III, which asked children to identify individual letters and words and is a test of early reading ($\alpha = 0.94$). Language skills were assessed with the WJ-III Picture Vocabulary subtest ($\alpha = 0.81$), which required that children identify objects that were depicted in a series of pictures. Math skills were assessed using the Applied Problems subtest ($\alpha = 0.93$), which requires that children perform basic math calculations in response to problems presented orally and the Quantitative Concepts subtest ($\alpha = 0.91$), which required children to complete number patterns. Children were assessed each fall and spring by trained data collectors in a quiet space outside of their classrooms. Children provided verbal assent to participate in the assessments and were returned to their classrooms if they asked to stop. They were given stickers to thank them for their participation after each task or assessment. Prior to conducting assessments, data collectors completed a full day of training on the measures and demonstrated proficiency with administration and scoring. Data collector training included protocols for obtaining verbal assent from children.

The pre-k assessment windows were November through January for the fall assessment (with 99.6% of children assessed in November and December) and March through May in the spring. The kindergarten assessment windows were September to December in the fall and April to June in the spring. Fall assessment windows were longer because it took time at the beginning of each school year for classroom rosters to be finalized, meaning that it took time to locate some children's classroom assignments. In pre-k we were also obtaining parent consent for each child in the fall before assessing them.

An additional teacher survey measure was included as a control variable to adjust for teachers' beliefs about children. The Ideas About Children Scale (also called the caregiver modernity scale; Schaefer & Edgerton, 1985) is a measure of child-centered versus adult-centered beliefs about children (e.g., *Children should always obey the teacher; Children have a right to their own point of view and should be allowed to express it*). It includes sixteen items rated on a 5-point scale from strongly

disagree to strongly agree. The scale had good internal consistency in the current sample ($\alpha = 0.78$). Teachers completed this scale in the fall both years.

Analytic approach

Piecewise multilevel growth modeling

Transitioning into kindergarten represents an abrupt change or shift in the circumstances surrounding students' development (Singer & Willett, 2003). To test the effects of this shift on students' language, literacy, and math skills, we used piecewise multilevel growth modeling. This approach models change over time for outcomes with repeated measures and allowed us to treat classroom processes as time-varying factors associated with concurrent levels of student functioning and with changes to the rate of growth after the transition (Singer & Willett, 2003). The analysis was conducted using the Stata mixed procedure to estimate parameters of interest and variance components (Rabe-Hesketh & Skrondal, 2012).

We used a two-level model with repeated measures of achievement nested within students. Over time, each child was nested within two classrooms (pre-k and kindergarten). Many children who attended pre-k together went into separate classrooms in kindergarten, resulting in approximately 900 pre-k-plus-kindergarten classroom combinations. We accounted for classroom-level nesting by adjusting standard errors for these different combinations of pre-k and kindergarten classroom clustering. Data collection timepoints were used as a metric of time for the overall slope: fall of pre-k (time = 0), spring of pre-k (time = 1), fall of kindergarten (time = 2), and spring of kindergarten (time = 3). Thus, model intercepts represent estimated mean academic scores across students at the beginning of pre-k. A second slope was coded for the time points after the transition into kindergarten (fall pre-k = 0, spring pre-k = 0, fall kindergarten = 1, spring kindergarten = 2), capturing the difference between the overall slope and the post-transition slope.

Classroom processes (teacher-child interactions, time on academic content, and academic rigor) were assessed once per year, so process scores were constant across times 0 and 1 (pre-k) and times 2 and 3 (kindergarten). At Level 1 (within student), classroom process variables were centered around each student's pre-k score so that the parameter estimates represented the effect of a one-unit change in a student's exposure to the classroom process across the transition from pre-k to kindergarten (referred to as "baseline centering" by Hoffman, 2015). In each model, interaction terms between the student-level classroom process and the post-transition slopes identified the effects of the discontinuities on students' rates of change after transitioning into kindergarten. At Level 2, pre-k process variables were centered around the grand mean and included in models to control for the level of each classroom process experienced by students in pre-k. Finally, a number of student level covariates were used to increase the precision of estimates, including student age at pre-k entry, gender, race/ethnicity, and family income-to-needs ratio. Models also controlled for teachers' adult-centered versus child-centered ideas about children and whether the student switched schools from pre-k to kindergarten.

Equations representing these models are as follows:

$$\text{Level 1}: Y_{ti} = \beta_{0i} + \beta_{1i}(time\ 1)_{ti} + \beta_{2i}(time\ 2)_{ti} + \beta_{3i} - \beta_{5i}(CWC\_Process)_{ti} + \beta_{6i} - \beta_{8i}(time\ 2{*}CWC\_Process)_{ti} + e_{ti}$$

$$\text{Level 2}: \beta_{0i} = \gamma_{00} + \gamma_{01} - \gamma_{03}(PreK\_Process)_i + \gamma_{0.}(Child\ Covariates)_i + r_i\,\beta_{1i} = \gamma_{10} + \gamma_{11} - \gamma_{13}(PreK\_Process)_i + \gamma_{1.}(Child\ Covariates)_i + r_i\,\beta_{2i} = \gamma_{20} + r_i$$

Cohen's *d* effect sizes were calculated by dividing coefficients by the pooled standard deviation of each outcome variable.

Missing data

Analyses for the current study relied on outcomes collected in the fall and spring of both pre-k and kindergarten. This included between 1121 and 1128 children of the original 1498 enrolled in the study who had data at any of the four time points for at least one of the sixteen outcomes (four assessments X four time points). In the sample consisting of non-attriters, there was little missing data on demographic characteristics on average (M = 7%; range = 0–22%), as these were measured at the baseline time point and provided by the school district. Outcomes were missing at rates of 16% (range = 10–25%) and 32% (range = 16–40%) on average, in pre-k and kindergarten, respectively. The modeling approach assumes that data are missing at random, conditional on controlling for all other variables within the model. Although some may prefer to handle missing data with full information maximum likelihood (FIML; Enders, 2001), such an approach is not appropriate in this case because of the inclusion of interactions in the models (Enders, Du, & Keller, 2020). An alternative approach is to impute the multilevel data and run the models to obtain the parameter estimates using a fully Bayesian approach in the Blimp software program (Enders et al., 2020). We present the findings from these alternate models in the supplementary online materials (Tables S1 and S2), as they did not differ substantially from the main set of results we discuss below.

Results

Descriptive information

Table 2 presents descriptive statistics for the four achievement outcomes. Means on the direct assessments suggest that students' achievement increased over time between each assessment time point. Converting the mean scores at each time point into approximate percentile ranks indicates that the means largely fell within the "average" range (25th to 75th percentiles), although the fall pre-k Picture Vocabulary mean was in the "low average" range (9th to 24th percentiles) based on the WJ-III norms and scored using the normative update (Mather & Woodcock, 2001; Schrank & Woodcock, 2007). On all subtests, children on average improved their standing relative to these norms from the fall of pre-k to the spring of kindergarten: for Letter-Word ID, from the 30th to 60th percentile; for Picture Vocabulary, from the 20th to the 25th percentile, for Applied Problems, from the 30th to the 42nd percentile; and for Quantitative Concepts, from the 25th to the 40th percentile. Variability on the measures (in terms of standard deviations) decreased substantially for Picture Vocabulary and Applied Problems over time, while variability on Letter-Word ID and Quantitative Concepts did not exhibit a consistent pattern.

Table 3 presents descriptive information about the classroom process variables, first in terms of classroom averages for pre-k and kindergarten classrooms, then in terms of the degree of difference children experienced across grades. In the analytic models that follow, differences between grades are treated as continuous variables, but for descriptive purposes only we present the proportions of children who experienced an *increase* in each indicator that was greater than 0.25 standard deviations (*SDs*), a *decrease* that was greater than 0.25 *SDs*, or *minimal change*, which we defined as a change between +/− 0.25 *SDs*. These results complement prior published findings (Vitiello et al., 2020) by showing that most children experienced decreases in the quality of teacher-child interactions, increased time on language/literacy and math content, and increased academic rigor of language/literacy and math instruction. Much smaller proportions of children experienced relative stability in classroom processes from pre-k to kindergarten.

Growth models

We first present information on the growth of students' math, language, and literacy skills across the study period, adjusting for other variables in the models. For each model in Table 4, the constant

Table 2
Descriptive statistics for child outcomes across Pre-k and kindergarten.

	Fall of pre-k		Spring of pre-k		Fall of K		Spring of K	
	M	SD	M	SD	M	SD	M	SD
Letter-Word ID	317.05	29.95	341.26	28.18	352.19	26.77	392.67	28.81
Picture Vocabulary	440.76	24.60	453.66	16.32	458.72	13.30	464.70	10.75
Applied Problems	380.55	31.90	403.28	23.54	414.74	21.16	436.15	18.42
Quantitative Concepts	405.62	14.84	418.98	16.77	428.08	16.35	446.39	13.11

Table 3
Comparisons of classroom experiences across Pre-k and kindergarten classrooms.

	Pre-K		Kindergarten		Prop. of children who experienced…		
	(*N* = 117)		(*N* = 289)		An increase >0.25 *SDs*	Minimal change− 0.25 to 0.25	A decrease >0.25 *SDs*
	M	SD	M	SD			
Teacher-child interactions							
Overall	4.44	0.47	4.06	0.50	0.19	0.21	0.60
Time on content							
Prop. Language/ literacy	0.11	0.09	0.41	0.14	0.63	0.00	0.37
Prop. math	0.03	0.05	0.21	0.11	0.76	0.00	0.24
Rigor of instruction							
Language/Literacy	0.10	1.34	1.75	1.38	0.83	0.06	0.11
Math	−0.89	1.70	0.93	1.81	0.77	0.07	0.16

Note. For descriptive purposes only, an "increase" was defined as a difference of 0.25 or more standard deviations between the pre-kindergarten and kindergarten averages; "minimal change" was defined as the difference between the pre-kindergarten and kindergarten averages between −0.25 and 0.25 standard deviations; and a "decrease" was defined as 0.25 standard deviations less than the difference between the pre-kindergarten and kindergarten averages.

Table 4
Classroom experiences and children's academic outcomes across Pre-k and kindergarten.

	Academic Outcomes											
	Literacy/language						Math					
	Letter-Word			Picture Vocabulary			Applied Problems			Quantitative Concepts		
	b *(SE)*	*p*	δ	*b* *(SE)*	*p*	δ	*b* *(SE)*	*p*	δ	*b* *(SE)*	*p*	δ
Growth Model												
Constant	198.90 (11.44)	***		414.89 (5.80)	***		289.33 (8.63)	***		338.23 (5.71)	***	
Slope 1	12.35 (1.52)	***	0.32	10.04 (0.84)	***	0.51	13.07 (1.24)	***	0.41	6.13 (0.78)	***	0.29
Slope 2	3.09 (1.17)	**	0.08	−7.55 (0.62)	***	−0.39	−5.25 (0.98)	***	−0.17	0.82 (0.65)		0.04
Teacher-child interactions												
Pre-k interactions	4.94 (1.44)	***	0.13	1.06 (0.86)		0.05	5.34 (1.38)	***	0.17	3.67 (0.79)	***	0.17
Increase from pre-k to K	6.57 (1.47)	***	0.17	1.70 (0.66)	**	0.09	2.25 (1.23)	+	0.07	1.90 (1.23)		0.09
Increase from pre-k to K x time 2	−3.02 (1.08)	**	−0.08	−0.87 (0.41)	*	−0.04	0.02 (0.78)		0.00	−0.41 (0.75)		−0.02
Time on content												
Pre-k prop. Literacy or math	−0.53 (0.66)		−0.01	−0.34 (0.37)		−0.02	−0.68 (0.65)		−0.02	−0.54 (0.37)		−0.03
Increase from pre-k to K	−9.08 (0.79)	***	−0.23	0.40 (0.43)		0.02	−3.20 (0.72)	***	−0.10	−2.83 (0.50)	***	−0.13
Increase from pre-k to K x time 2	5.34 (0.65)	***	0.14	−0.39 (0.25)		−0.02	2.08 (0.47)	***	0.07	2.04 (0.34)	***	0.10
Rigor of instruction												
Pre-k literacy or math rigor	0.29 (0.58)		0.01	0.61 (0.31)	+	0.03	0.06 (0.39)		0.00	−0.16 (0.24)		−0.01
Increase from pre-k to K	−2.96 (0.55)	***	−0.08	0.11 (0.32)		0.01	−0.10 (0.38)		0.00	−0.56 (0.30)	+	−0.03
Increase from pre-k to K x time 2	1.71 (0.39)	***	0.04	0.04 (0.18)		0.00	0.09 (0.24)		0.00	0.34 (0.18)	+	0.02

Note. Standard errors (in parentheses) were adjusted for pre-k and K classroom clustering. Covariates include: child age, gender (reference = male), race (reference = white), home language (reference = English), family income-to-needs ratio, whether the child switched schools from pre-k to K, and teachers' ideas about children. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

represents the estimated mean across students at the fall pre-k time point after adjusting for all covariates. The Slope 1 coefficient represents the average rate of change between any two consecutive time points. The Slope 2 coefficient represents the difference – acceleration or deceleration – in the rate of change observed in kindergarten as compared with the overall rate of change. The results therefore indicate that students showed significant gains in language, literacy, and math achievement from the start of pre-k through kindergarten. For Letter-Word ID, students learned at a faster rate in kindergarten than they had in pre-k. For Picture Vocabulary and Applied Problems, students learned as a slower rate in kindergarten than they had in pre-k. Lastly, for Quantitative Concepts, there was no change in the rate of learning between the two grades.

Predicting child outcomes from differences in teacher-child interactions

Controlling for the level of teacher-child interactions that children experienced in pre-k, a one-unit increase in interaction quality from pre-k to kindergarten was associated with slightly but significantly higher scores on Letter-Word ID ($d = 0.17$) and Picture Vocabulary ($d = 0.09$) at kindergarten entry (Table 4). However, an increase in interaction quality from pre-k to kindergarten was also associated with a decrease in the rate of change in kindergarten for Letter-Word ID ($d = -0.08$) and Picture Vocabulary ($d = -0.04$). It is worth noting here that the majority of children experienced a *decrease* in the quality of teacher-child interactions between pre-k and kindergarten, which would translate into lower academic performance than otherwise expected in the fall of the kindergarten year followed by a faster rate of change in kindergarten. As depicted in Fig. 1, the contrasting coefficients associated with kindergarten entry skills and kindergarten gains suggest that students' Letter-Word ID and Picture Vocabulary scores "rebounded" from the small effects associated with the discontinuity.

Predicting child outcomes from differences in time on literacy and math content

For these models, language and literacy outcomes were modeled using the proportion of observed time on language and literacy content, while math outcomes were modeled using the proportion of observed time on math content (Table 4). Controlling for the time on content that each student experienced in pre-k, a one-unit increase in time on content from pre-k to kindergarten was associated with lower than expected Letter-Word ID ($d = -0.23$), Applied Problems (d = −0.10), and Quantitative Concepts ($d = -0.13$) at the start of kindergarten. An increase in time on content was also associated with increased rates of change across the kindergarten year for those three outcomes ($ds = 0.14$, 0.07, and 0.10, respectively). Time on content showed no associations with vocabulary learning. As above, the results suggest that students' learning rebounded at least partially from the effects associated with experiencing larger differences. The significant effect of time on math predicting Applied Problems is plotted in Fig. 2.

Predicting child outcomes from differences in academic rigor

Language and literacy outcomes were modeled using teacher reports of academic rigor in language and literacy content, while math outcomes were modeled using math academic rigor (Table 4). Controlling for the academic rigor that each student experienced in pre-k, a one-unit increase in rigor was associated with lower-than-expected Letter-Word ID ($d = -0.08$) in the fall of kindergarten. An increase in academic rigor was associated with a slightly but significantly increased rate of change across the kindergarten year for Letter Word ID ($d = 0.04$). Academic rigor showed no significant associations with Picture Vocabulary, Applied Problems or Quantitative Concepts. As illustrated in Fig. 3, differences in students' fall kindergarten scores associated with the discrepancy were very small and converged over time.

Discussion

The transition from pre-k into kindergarten comes during a developmental period characterized by rapid change and relative malleability (Cantor, Osher, Berg, Steyer, & Rose, 2019). Given its potential long-term implications for children's academic and psychosocial well-being, early childhood researchers and practitioners have long been concerned with easing the transition and ensuring that both pre-k and kindergarten experiences provide supports that will lead to positive developmental outcomes (Stipek et al., 2017). However, little or no prior research has examined whether and how experiencing differences between pre-k and kindergarten environments is associated with students' academic development. Results of this analysis suggest that students are affected negatively by common discrepancies in academic supports: decreased quality of teacher-child interactions, increased time

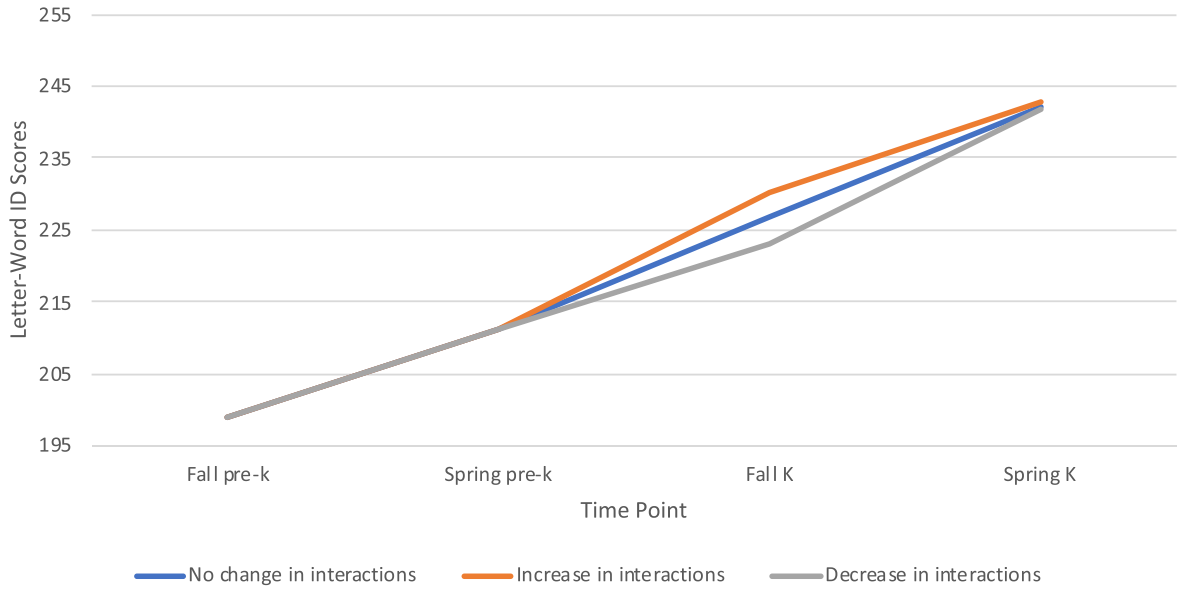

Fig. 1. Associations between context differences in teacher-child interactions and students' letter-word ID.
Note. This figure plots trajectories for children who experienced pre-k teacher-child interactions at the group mean for pre-k.

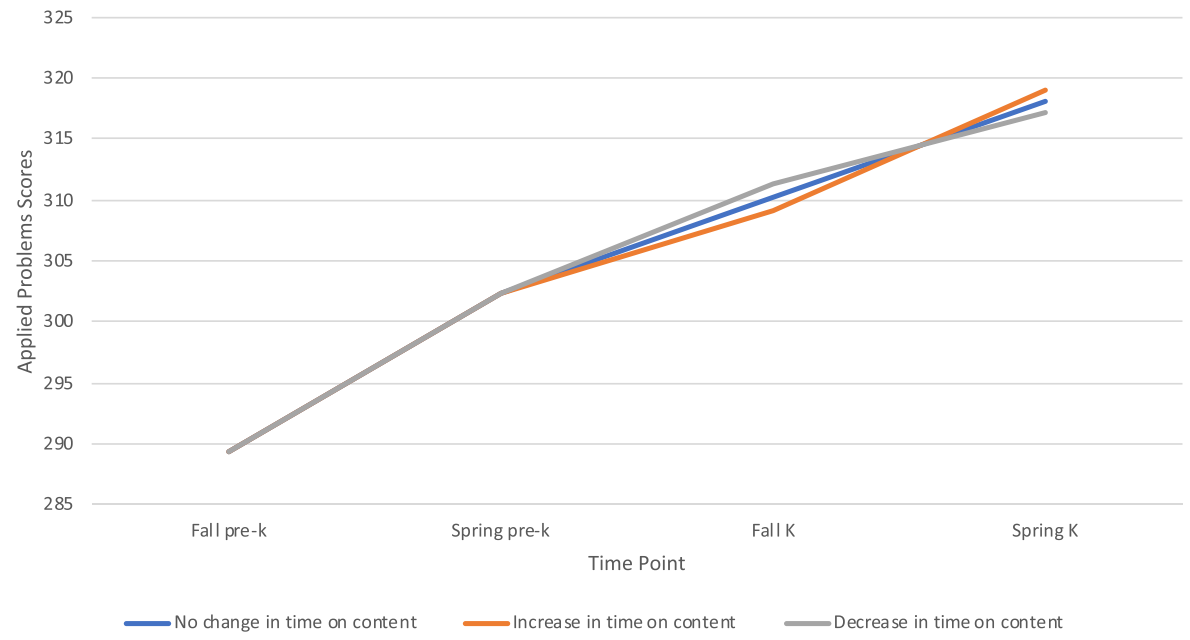

Fig. 2. Associations between context differences in time on math content and students' applied problems.
Note. This figure plots trajectories for children who experienced pre-k time on math content at the group mean for pre-k.

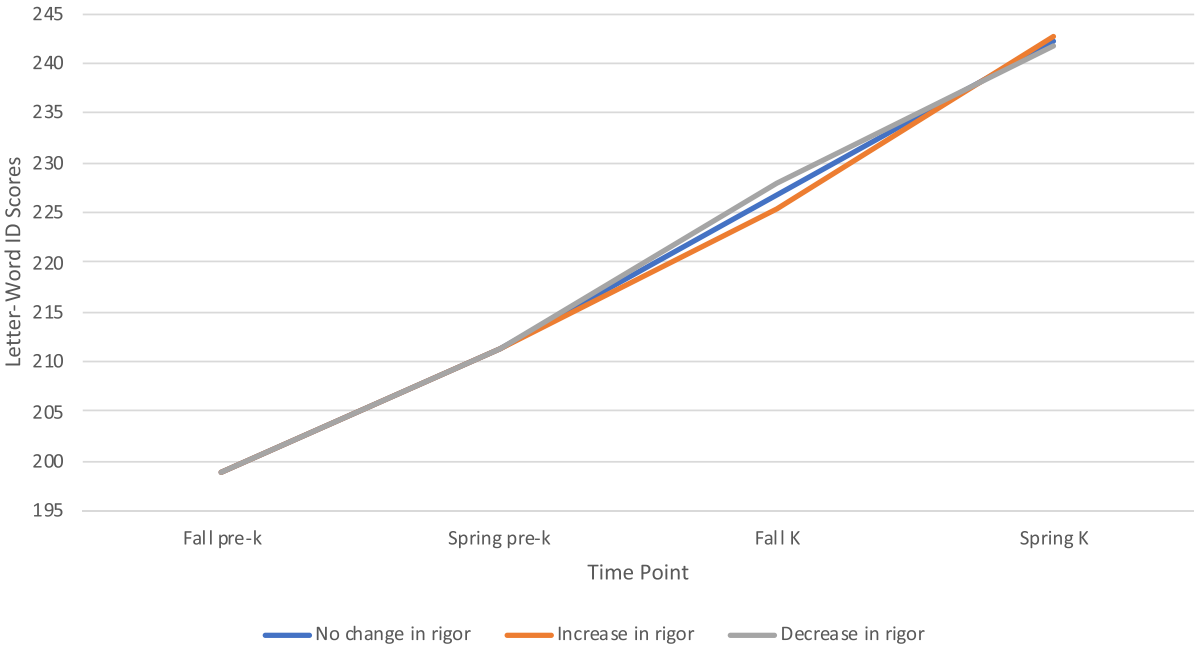

Fig. 3. Associations between context differences in academic rigor and students' letter-word ID.
Note. This figure plots trajectories for children who experienced pre-k academic rigor at the group mean for pre-k.

on instructional content, and increased academic rigor. However, results also suggest that the effects are small and that students are largely resilient to these effects over time.

This study produced evidence that larger differences between the pre-k and kindergarten academic environments were associated with variability in students' academic skills in the fall of kindergarten. For teacher-child interactions, as expected, experiencing a decrease in the quality of interactions was associated with lower-than-expected academic scores in literacy, vocabulary, and math. For time on content and academic rigor – for which we did not have directional hypotheses – larger increases from pre-k to kindergarten were associated with poorer academic skills. These associations were more consistent for differences children experienced in teacher-child interactions (Letter-Word ID and Picture Vocabulary) and time on content (Letter-Word ID, Applied Problems, and Quantitative Concepts) than for academic rigor (Letter-Word ID).

It is not clear why differences between contexts are associated with lower-than-expected academic scores at kindergarten entry. It may be that inconsistency in academic supports leads children to struggle academically during the first months of school, or that some kindergarten classrooms present children with academic supports that are poorly matched to children's skills (Claessens et al., 2014; Engel et al., 2016; Ritchie, Clifford, Malloy, Cobb, & Crawford, 2010). There may be reasons rooted in the cognitive science of learning and memory; for

example, children may have difficulty recalling or performing academic skills in highly unfamiliar contexts. A similar phenomenon, context-dependent memory, has been widely studied in cognitive and learning sciences and suggests that people are better at recalling information they learned when the initial presentation and the recall task are presented in the same context (Unsworth et al., 2012). However, this has been studied mostly in adults and over relatively short-term intervals, so it is not clear whether this phenomenon is related to the associations seen here, although the relatively small effects and subsequent rebound from fall to spring may indicate that there was some level of cognitive interference rather than true effects on learning.

Another possibility along these lines is that larger differences are stressful for children during the transition into kindergarten. There is some evidence that transitioning into a new educational setting causes stress (Bernard, Peloso, Laurenceau, Zhang, & Dozier, 2015; Quas, Murowchick, Bensadoun, & Boyce, 2002; Rickmeyer, Lebiger-Vogel, & Leuzinger-Bohleber, 2017), and that the magnitude of differences between environments may heighten children's stress (Quas et al., 2002). Stress disrupts children's cognitive control and can affect children's attention and working memory, which may lead to difficulty attending to testing or recalling information from memory.

Although the mechanism for the current study's findings are not clear, these options present several directions for further research. Researchers may try to determine whether children experience cognitively salient levels of stress when transitioning into a new and different classroom environment or examine whether the hypothesized effects on fall academic skills are lower when schools and teachers make greater efforts at alignment across grades. It may be necessary to better understand the mechanism behind these associations in order to address them effectively.

Importantly, the negative associations between context differences and academic performance were small and largely did not persist across the kindergarten year. In all cases, models implied that children who experienced larger differences made up most of the initial lower-than-expected achievement compared to peers who experienced smaller differences between contexts. The rebound was most pronounced for differences in time spent on content. There is little research to guide decisions about how much class time should be devoted to academic learning or to different content areas, but this finding suggests that spending a greater proportion of the kindergarten day on math and literacy helped children recover from the effects associated with the discontinuities children experienced at the start of the year.

Implications for policy and research

Although this work cannot be used to draw causal inferences and therefore does not have direct policy implications, it does lend support to the idea that lack of continuity across pre-k and kindergarten is difficult for children academically, at least toward the start of the school year. There is substantial writing on what might be needed to bring pre-k and kindergarten into greater alignment with each other, and here we reiterate some of those suggestions as they apply to the current findings. The transition to school should be conceptualized as the entire period in which children prepare for and settle into kindergarten, encompassing the last several months of pre-k and the first months of kindergarten (Ramey & Ramey, 2010). During this period, teachers and administrators in pre-k and kindergarten should collaborate across grades to structure coherent experiences for children, including continuity in academic content as well as in pedagogical and relationship-building practices (Kagan, 2010; Stipek et al., 2017). One approach that could facilitate academic continuity would be to encourage teachers to understand and teach in terms of learning progressions, predictable stages in the development of specific academic skills, so that instruction can be delivered at appropriate levels for children entering school with diverse skills (Sarama et al., 2021; Stipek et al., 2017). Lastly, communities can develop definitions of high-quality instruction for early childhood that span pre-k and kindergarten and seek to maintain high quality across the early years (Yelverton & Mashburn, 2018).

Additional research is needed to better understand how children are affected by the transition into kindergarten. Critically, the current study operationalized transition experiences in terms of context *differences* between grade levels. We did not examine whether *continuity* in experiences was beneficial for children. For teacher-child interactions, there is evidence that experiencing stable, high-quality interactions over two years supports children's positive development, while inconsistent and stable low quality are detrimental (Cash et al., 2019; Vernon-Feagans et al., 2019). There is no similar evidence base regarding time on instruction or academic rigor across pre-k and kindergarten.

Another key area for further work is to determine whether interventions can bring pre-k and kindergarten into greater alignment, and whether alignment benefits children. Research to date has largely focused on the use of transition practices, which can include collaboration between pre-k and kindergarten teachers and other high-level efforts to improve alignment (Zulfiqar et al., 2018). One recent program evaluation indicated that efforts to smooth transitions and support curricular alignment from pre-k to kindergarten helped children maintain the benefits of an enriched pre-k math curriculum (Sarama & Clements, 2018). Other large-scale pre-k programs, such as the pre-k program run by Boston Public Schools, explicitly focus on curricular alignment between pre-k and kindergarten (McCormick et al., 2020) and preliminary results suggest that this approach may be effective at maintaining some of the benefits of pre-k enrollment into elementary school (McCormick, Hsueh, Weiland, Snow, & Sachs, 2020). However, strong evidence in support of these approaches is lacking.

Limitations

This work has several important limitations. First, the data collection windows were relatively long and were not timed to capture children's immediate transition experiences. For example, observation data was collected throughout the pre-k and kindergarten years, and fall child assessments were collected over the course of several months. Future studies designed to capture transition experiences should try to have tighter and earlier fall assessment windows and observation data from the spring of pre-k and early fall of kindergarten. Based on CLASS observation validity data suggesting relative stability over time (Pianta et al., 2008) and our own lack of correlation between kindergarten observation date and CLASS score, we believe that the CLASS scores in the current data adequately capture a stable aspect of classrooms' teacher-child interaction quality. Regarding the timing of assessments, it is likely that children made some achievement gains during the first two months of kindergarten, so the estimates we present here may underestimate the initial effects of differences between pre-k and kindergarten.

Additionally, there may be other factors that account for changes in children's skills between the spring pre-k and fall kindergarten assessments. For example, there may have been differences in children's access to cognitively enriching experiences over the summer, which is known to support continued academic gains (McCombs, Augustine, Pane, & Schweig, 2020). There may be other aspects of children's early experiences in kindergarten, such as the alignment of content with children's skills (Claessens et al., 2014) or the use of culturally sensitive practices (Iruka, Curenton, Durden, & Escayg, 2020) that are key to building upon skills learned in pre-k. There is also data suggesting that participating in transition activities, like attending a school orientation or receiving information from the child's new school can support academic development (Schulting, Malone, & Dodge, 2005). These factors warrant further investigation in concert with better understanding how the degree of change in children's contexts affect learning.

Because this study presents observational research, results cannot support causal conclusions. This study was also conducted within a single school district that has a high degree of racial and linguistic

diversity, and the findings may not generalize to school divisions that are demographically dissimilar. Additionally, the use of piecewise longitudinal modeling provides one lens on how transitions are associated with child outcomes, but there are other ways of conceptualizing transitions that warrant further study; for example, operationalizing transition experiences in terms of continuity instead of discontinuity or difference. Despite these limitations, this study provides further evidence that context differences experienced during the transition into kindergarten are difficult for children and may have small, negative effects on academic development.

Conclusions

Despite decades of research, there remain many aspects of early childhood education that are still poorly understood. Among these, there has been little research to determine whether and how continuity and discontinuity of classroom experiences affect children as they transition into kindergarten. The current study suggests that children enrolled in public pre-k are negatively affected by certain types of discrepant experiences at the start of the school year – particularly those that involve exposure to substantial decreases in the quality of teacher-child interactions and increases in time on academic content – although the effects are relatively modest and children recover their relative learning losses across the kindergarten year. More research and intervention work will help us better understand and contextualize these findings and help us determine whether and how to address discontinuities to better support development.

CRediT authorship contribution statement

Virginia E. Vitiello: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition. **Tutrang Nguyen:** Conceptualization, Formal analysis, Writing – original draft. **Erik Ruzek:** Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Supervision, Funding acquisition. **Robert C. Pianta:** Conceptualization, Methodology, Investigation, Supervision, Project administration, Funding acquisition, Writing – review & editing. **Jessica Vick Whittaker:** Conceptualization, Methodology, Investigation, Supervision, Funding acquisition, Writing – review & editing.

Declaration of Competing Interest

none.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appdev.2022.101396.

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