MULTI-GRADE KINDERGARTEN CLASSROOMS AND CHILDREN'S ACADEMIC ACHIEVEMENT,
EXECUTIVE FUNCTION, AND SOCIO-EMOTIONAL DEVELOPMENT

Running Head: Multi-grade Kindergarten Classrooms
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Arya Ansari
University of Virginia

Abstract

Using data from the Early Childhood Longitudinal Study Kindergarten Class of 2010-2011 (ECLS-K: 2011; $n = 11,000$), this study examined the developmental outcomes of 5-year-old children in multi-grade classrooms (combined pre-kindergarten and kindergarten classrooms serving 3-, 4-, and 5-year-olds) compared with 5-year-olds attending kindergarten-only classrooms serving primarily 5-year-olds. Results from regression and propensity score analyses revealed that 5-year-old children who attended multi-grade classrooms with pre-kindergarteners made smaller gains in math and literacy skills and demonstrated less optimal executive function at the end of the school year as compared with children who attended kindergarten-only classrooms. Classroom-level factors largely explained the differences in children's academic achievement but did not consistently explain differences in their executive functioning. No consistent differences emerged for children's social-behavioral development.

Keywords: Multi-grade kindergarten classrooms; ECLS-K: 2011; Academic achievement; Executive function; Socio-emotional skills

The multi-grade education philosophy—defined as grouping children of two or more grades into a single classroom—has long been a part of the U.S. educational system (Little, 2001; Veenman, 1995; Vincent, 1999). During the early elementary school years, these classrooms serve up to 5% of children across the country (Thomas, 2012) and although they are often encouraged from an educational standpoint, they typically arise because of economic and logistical constraints (Burns & Mason, 2002; Little, 2001; Veenman, 1995). Whether these classrooms help (or hinder) children's school success, however, has been a subject of great debate. Grounded in developmental theories of cognitive development (Vytgotsky, 1978) and social learning (Bandura, 1986), some scholars argue that multi-grade classrooms can be more effective than the single-grade model because children of various skills can stimulate each other's learning through modeling and scaffolding (Veenman, 1995). In contrast, other scholars posit that children in multi-grade classrooms may exhibit fewer gains in early learning and development because teachers may provide children with less challenging content as a means of accommodating a wide range of skill levels, resulting in disengagement among older and more skilled children (Mason & Burns, 1996; Urberg & Kaplan, 1986).

Given the conflicting empirical evidence and the long-standing model of single-grade education, multi-grade classrooms require continued attention. Such inquiry is especially necessary during the early elementary school years when children's skills are more malleable (Bornstein, Hahn, Putnick, & Suwalsky, 2014), and kindergarten in particular, which has grown exponentially over the last several decades (Davis & Bauman, 2013) and constitutes a critical developmental period for shaping children's long-term life success (Duncan et al., 2007; Entwisle & Alexander, 1989; Jones et al., 2015). Thus, with the rise in the number of children attending kindergarten, coupled with the heightened emphasis on children's early learning (Bassok, Latham, & Rorem, 2016), we need to know whether the multi-grade model is more or

less effective than the single-grade model when implemented during the transition to school. The

current study addresses these gaps in the literature by using data from the Early Childhood

Longitudinal Study Kindergarten Class of 2010-2011 and contrasting the early learning of 5-

year-olds attending multi-grade classrooms that serve both preschoolers and kindergarteners and

kindergarten-only classrooms. It should be noted this study cannot speak to the benefits or

drawbacks of these two types programs for: (a) the younger children (e.g., 3- and 4-year-olds);

and (b) for 5-year-olds enrolled in classrooms with older children, as these types of questions are

beyond the scope of this study and the data available.

Multi-Grade Classrooms and the Transition to School

Regardless of whether multi-grade classrooms are put into practice for pedagogical or

logistical reasons, the evidence behind multi-grade education is methodologically limited and has

focused on the experiences of older children in the later elementary school years (e.g., first or

second grade and beyond) rather than of children during the transition to school (Veenman,

1995). Prior evaluations of multi-grade educational programs have also been ambiguous. Studies

of multi-grade classrooms in Virginia (second to fifth grade, Spratt, 1986), New York (second to

fifth grade, Way, 1981), and California (kindergarten to third grade, Purl & Curtis, 1970) have

demonstrated academic effects that were positive, negative, and statistically indistinguishable,

respectively, and that aggregate to zero (Pratt, 1986; Veenman, 1995). Similarly, analyses of

elementary schools that have transitioned from a single-grade to multi-grade model for children

between the first and eighth grade years have demonstrated no significant changes in children's

test scores (Proehl, Dogulas, Elias, Johnson, & Westsmith, 2013). In other words, despite the

strong and long-standing advocacy in support of multi-grade educational programs (e.g., Katz,

Evangelou, Hartman, 1990), the extant literature suggests that the multi-grade education model

produces similar academic outcomes as compared with the single-grade model.

Most of these studies, and the multi-grade literature more generally, have been unable to adequately address issues of selection, which may also contribute to differential effects across studies and potentially bias findings in support for the multi-grade philosophy (see, Mason & Burns, 1996). In other words, children are not randomly assigned to multi-grade and/or single-grade classrooms, but rather, parents select whether to send their children to these schools, which may also affect the child outcomes in question. Moreover, other economic and geographical reasons might also be at play (e.g., there are no other alternative programs available). For example, more experienced teachers are more likely to teach multi-grade classrooms and these classrooms generally serve more advantaged children (Mason & Burns, 1996); therefore, any observed benefits of multi-grade classrooms might be due to the socio-economic and educational advantages of parents and teachers rather than children's educational experiences in multi-grade classrooms. Thus, despite the fact that multi-grade education dates back well over a century, the research on this educational practice has remained in its early stages.

There are a few recent exceptions, however. In an analysis of the ECLS-K: 1998 cohort, Thomas (2012) found no differences in the educational outcomes of first-graders who experienced multi-grade (combination of kindergarten and first grade or first and second grade) versus single-grade education. Unlike much of the existing literature, this study was able to account for a rich set of child-, family-, and school-level characteristics as a means of ruling out confounding factors. In contrast to these national data, in a quasi-experimental analysis of the Los Angeles School District, Mariano and Kirby (2009) found that multi-grade classrooms had a negative (roughly 10% of a standard deviation), effect on student achievement across the elementary school years, even when examining the average treatment effect on the treated through propensity score techniques. Similarly, analyses of elementary schools across the state of California have revealed that the implementation of multi-grade classrooms for children in the

second and third grade years resulted in lower test scores, with effects corresponding to 6-10% of a standard deviation.

Of note is that each of these studies have generally focused on children of older ages (first through fifth grade), which is critical as multi-grade and mixed-aged classrooms may be particularly harmful for younger children. For example, recent analyses of the Head Start program revealed that 4-year-old children who were enrolled in mixed age classroom performed less well on assessments of math and literacy as compared with 4-year-olds who attended classrooms with fewer younger children (Ansari, Purtell, & Gershoff, 2016). Similar patterns have emerged in other evaluations of preschool programs from urban cities in the northeastern United States (Moller, Forbes-Jones, Hightower, 2008). Consequently, the costs and benefits of modern-day multi-grade and mixed-age classrooms are unclear, especially during the transition to school, which has long-term implications for children's life success (Duncan et al., 2007).

Mechanisms Underlying the Differences across Multi- and Single-grade Classrooms

The mechanisms through which multi-grade classrooms operate are also relatively unknown, with one of the primary hypothesized pathways being peer learning. Social learning theory suggests that, during these early years, learning often occurs through modeling, whereby younger children can observe older and more competent children in the classroom and mimic their behaviors and actions (Bandura, 1986). Additionally, older children can scaffold younger children who, in turn, develop more independence and build on their kindergarten skills by reinforcing each other's abilities and, as part of this scaffolding process, older children can cement their own skills and knowledge (Vytogsky, 1978). These principles of cognitive and social-learning theories are the bedrock for the multi-grade educational philosophy and underlie the peer effects literature (Justice, Logan, Lin, & Kaderavek, 2014; Mashburn, Justice, Downer, & Pianta, 2009), which demonstrates that classmates can (and do) affect children's learning.

Advocates of multi-grade education also argue that these classrooms can promote the school success of children by reducing the rigid expectations that result from single-grade classrooms. In other words, children can learn at their own paces and skill levels (Katz et al. 1990), in part because teachers focus their instruction and daily activities on children's individual needs as opposed to the grade-level expectations. In an ideal classroom, even the oldest children should receive the appropriate degree of novel instructional stimulation as compared with children in single-grade classrooms. Thus, multi-grade classrooms can provide teachers with a unique means of meeting the developmental needs of children of varying ages and abilities; whether these theories work in practice, especially for older and more advanced children within a classroom, has remained contested (Ansari et al., 2016; Bell et al., 2013; Justice et al., 2014; Moller et al., 2008).

In contrast, opponents of multi-grade education argue that these classrooms may be less conducive for children's learning and development for a number of reasons (Mason & Burns, 1996). For example, there is a growing body of literature suggesting that children's own abilities shape and influence classroom standards and processes (Nurmi & Kiuru, 2015) so that, in practice, multi-grade teachers often end up providing less individualized attention and less challenging content to older children in the classroom (Mason & Burns, 1996). Teachers in multi-grade classrooms may also have a more challenging time managing children who display a wide range of academic and behavioral skills. Consequently, these teachers may have less time to dedicate to whole group and small group instruction and, instead, may spend a greater amount of time on classroom management and discipline, which may slow children's academic growth (Mason & Burns, 1996). Regardless of whether these pathways are direct or indirect, or whether these effects are positive or negative, these classrooms present a unique opportunity to answer a

basic developmental question that has received conflicting empirical support: whether the eldest children make greater academic gains when they are with same-age or different aged peers.

The Current Study

This study attempts to bridge these gaps in knowledge by using data from the nationally representative ECLS-K class of 2010-2011 to address three research questions: (1) What is the current prevalence of multi-grade and kindergarten-only classrooms and what characteristics distinguish them?; (2) How do the educational outcomes of 5-year-old children in multi-grade classrooms compare with those of 5-year-olds in kindergarten-only classrooms?; And (3) What are the mechanisms through which multi-grade classrooms affect 5-year-old's school success? Given the mixed evidenced regarding the benefits of multi-grade classrooms, I did not make directional hypotheses. In addressing these questions, however, this study considers 5-year-old's academic outcomes as well as their executive function and socio-emotional development, both of which shape children's short- and long-term school success (Masten et al., 2012; McClelland et al., 2013). Finally, this study also considers classroom organization, management and discipline, instructional delivery, and self-directed and peer learning as possible mechanisms for differential effects across multi-grade and kindergarten-only classrooms.

In sum, this study is poised to fill a critical gap in the existing literature that has provided mixed empirical support for the effectiveness and efficacy of multi-grade education during the early elementary school years. This investigation builds on the work of Thomas (2012) by shifting the attention from the implementation of multi-grade education during the first grade year to kindergarten, and using the most recent cohort of the ECLS-K. Thus, the findings reported herein have potential implications for both developmental theory and educational policy during a period of heightened accountability: on the one hand, if contemporary multi-grade kindergarten classrooms have a deleterious effect for children's educational outcomes, then

programs that use these models need to be re-evaluated; on the other, if these programs foster children's school success, then multi-grade classrooms may present a unique opportunity to educate young children during the transition to formal schooling. Finally, not only can this study delve into the pros and cons of multi-grade education, but it can also help determine why these educational programs influence children's developmental outcomes.

Method

This study used a nationally representative sample of kindergarteners drawn from the ECLS-K class of 2010-2011 (see Tourangeau et al., 2014). The ECLS-K included approximately 18,760 children in both part- and full-day kindergarten programs across 970 schools in the U.S. The first stage of sampling was based on 90 primary sampling units (PSUs), which were selected from a national sample that represented different counties and geographic areas. At the second stage, 1,310 schools (80% public) were selected within the PSUs, with 970 eventually participating. Finally, in the third stage, up to 23 kindergarteners were selected per school. It is important to note that the ECLS-K sampling frame was based on kindergarten enrollment, not child age; thus, the results of this study reflect families with kindergarteners during the 2010-2011 school year (for more information on sampling see, Tourangeau et al., 2014). To date, these children have been followed through the end of the fourth grade year and data were collected from multiple informants including direct child assessments as well as parent, caregiver, and teacher reports of the home, community, and school context.

For the purposes of the current study, children were required to have: (a) a valid longitudinal weight, ensuring that the data are nationally representative of the larger population of children and families (and correcting for non-random attrition); (b) been enrolled in a classroom that served only kindergarteners or served both pre-kindergarteners and kindergarteners (more details provided below); and (c) been enrolled in a full day kindergarten

classroom. The first exclusion criterion was in place because children without a longitudinal

weight were those who left the study sample by the end of kindergarten and, thus, did not

experience a full year in multi-grade or single-grade classrooms. The second exclusion criterion

meant that teachers who reported that they taught a classroom that included any grade beyond

pre-kindergarten or kindergarten were excluded from these analyses. These children were

excluded because the purpose of the study was to examine the effects of being a 5-year-old in a

classroom with pre-kindergarteners. Finally, the last exclusion factor was due to the fact that a

large number of multi-grade kindergarten classrooms were full-day programs. These three

exclusion factors resulted in a final sample of 11,000 children (per IES/NCES guidelines, all

sample sizes have been rounded to the nearest 10). See Table 1 for sample descriptives.

Measures.

Weighted descriptive statistics for the focal variables are presented in Tables 1 and 2,

separated by type of kindergarten class (i.e., kindergarten-only versus multi-grade classrooms).

All reported reliabilities are from the ECLS-K: 2011 user's manual (Tourangeau et al., 2014).

Multi-grade classrooms. During the start of the school year, teachers reported whether

they taught a multi-grade classroom and, if so, what grade levels were included. Options

included pre-kindergarten, transitional kindergarten, regular kindergarten, first grade, second

grade, and third grade or higher. Teachers who said that they did not teach a multi-grade

classroom and/or reported that their class only served kindergartens were classified as teaching a

kindergarten-only classroom. In contrast, teachers who answered "yes" to teaching a multi-grade

classroom and reported that one of the grade levels included pre-kindergarten and a regular

kindergarten, were classified as multi-grade. Children were also classified as being enrolled in a

multi-grade classroom if teachers reported that they did not teach a multi-grade class (or they did

not respond to this question), but noted that their class served both pre-kindergarteners and

kindergarteners. Thus, multi-grade kindergarten classrooms were those that served both pre-kindergarteners and kindergartners, whereas kindergarten-only classrooms were those that served strictly kindergarteners.

Academic achievement. Children's academic achievement was assessed at the beginning and end of the school year using two measures developed specifically for the ECLS-K and were based on national and state standards. The reading assessment (T1 and T2 α's = .95) measured children's print familiarity, letter recognition, decoding, and vocabulary knowledge, whereas the math assessment (T1 α = .92 and T2 α =.94) captured children's problem solving, geometry and spatial sense, and measurement skills. For the purposes of this study, the Item Response Theory (IRT) scores were used, which allows for the estimation of growth over time. These scores were generated based on the pattern of right and wrong responses to the questions administered in an assessment and adjusted for the possibility of children guessing several difficult items correctly.

Executive function. Two facets of children's executive function were directly assessed: (a) cognitive flexibility, which was assessed using the Dimensional Change Card Sort (DCCS; Zelazo 2006); and (b) working memory, which was assessed using the Numbers Reversed subtest of the Woodcock-Johnson (NR-WJ; Mather and Woodcock 2001). During the DCCS assessment, children were asked to sort cards into different trays based on rules (e.g., by shape or by color) that changed periodically. Children's scores on the DCCS were based on a combination of accuracy and reaction time. In contrast, during the NR-WJ, children were asked to repeat a series of numbers that were dictated to the child, backwards. If children responded incorrectly to a series of numbers, then the task ended; if, however, children respond correctly, then the number span increased by one digit at a time. For the purposes of this study, the W score was used for the NR-WJ assessment and the combined score was used for the DCCS. The W scores were generated using norming data provided by the publishers which are a function of a child's

raw score, age, and the language of assessment (Spanish or English). It should be noted that

unlike the IRT scores for math and reading, the W scores only account for the total number of

administered sequences answered correctly and do not reflect the pattern of response.

Social-emotional skills. During the fall and spring of the kindergarten year, teachers

reported on four different dimensions of children's social-emotional development using

subscales from the Social Skills Rating System (SSRS; Gresham & Elliott, 1990): attentional

control, internalizing and externalizing behavior problems, and social skills. The SSRS is based

on a 4-point Likert scale (0 = *never* to 3 = *very often*) and has demonstrated adequate reliability

in the ECLS-K (α's across waves and subscales = .78-.89)

Classroom mediators. During the spring of the kindergarten year, teachers reported: (a)

how many days per week they taught reading/language arts and mathematics (0 = *never* to 7 = *5

days week*); and (b) on the days they taught these subjects, how many hours children spent

working on lessons or projects within these subject areas (0 = *never* to 8 = *3 hours or more*).

Teachers' responses to these two questions were cross-classified to generate an estimate for the

hours per week children spent working on math and literacy activities. Teachers also reported

how much time each day children in their classroom spent in teacher-directed whole class

activities, teacher-directed small group activities, teacher-directed individual activities, and

child-selected activities with responses ranging from 0 (*never*) to 6 (*4 hours or more*). Because

teachers did not report how many days per week children spent in the aforementioned activities,

it was assumed that these activities were done each day so that all classroom-level variables

would be on the same metric (i.e., hours per week). Thus, teachers' responses were multiplied by

five to generate an estimate for approximately how long children spent in whole class, small

group, child-selected, and individualized activities each week. Teachers also reported how much

time each day was spent on classroom discipline or handling disruptive behavior. Responses

ranged from 0 (*less than 30 minutes a day*) to 6 (*3 hours or more a day*). To translate these

estimates to hours per week, these responses were also multiplied by five days. Next, during the

end of the school year, teachers reported how many children in their classroom (including those

not sampled in the ECLS-K) were below grade level in reading and math. These reports were

divided by the number of children in the classroom to generate an estimate for the percent of

children in the classroom scoring below grade level. Due to high overlap between the percent of

children who scored below grade level in math and reading, the average of the two was taken.

Finally, teachers rated the classroom-level behavior on a scale of 1 (*group misbehaves*

frequently) to 5 (*group behaves exceptionally well*).

      Covariates. All models adjusted for a full set of child-, family-, household-, and school-

level covariates that were drawn from the fall wave of data collection (see Table 1): child age,

child gender, child race/ethnicity, home language, whether child was a first time kindergartener,

whether child was diagnosed with a disability, parents' years of education, parents' age, whether

parents were married, parents' employment status, household income, number of children in the

household, region, urbanicity, class size, teachers' years of experience, teachers' years of

education, change in teachers across the school year, school sector, percent of minority children

enrolled at the child's school, percent of children eligible for free/reduced lunch, and school size.

Analytic Strategy

      All analyses were estimated in Stata (version 14; StataCorp, 2009) and Mplus (version 7;

Muthén & Muthén, 1998-2013). Stata was primarily used to address missing data, generate

sample descriptives, and for propensity score matching (discussed in more depth below),

whereas Mplus was used for the focal multivariate analyses. Missing data were minimal (mean =

5%, range = 0-20%) and did not systematically vary as a function of classroom type. The highest

levels of missing data were for indicators of children's disability status, household income, and

some of the school/classroom characteristics (e.g., percent minority and percent of children

below grade level in academics). In order to maximize the sample size, missing data were

addressed through 50 imputed datasets using the chained equations method in Stata (Azur,

Stuart, Frangakis, & Leaf, 2011). The multilevel nature of data were accounted for by using

clustered standard errors at the school level (see also, Weiland & Yoshikawa, 2014) and all

models included the longitudinal kindergarten weight to account for stratification and cross-wave

attrition. For each outcome, two sets of models were estimated in Mplus. In Model 1, the

outcomes of interest were individually regressed on the covariates and an indicator of whether

children were enrolled in a kindergarten only (0) or a multi-grade classroom (1). Then, in Model

2, the classroom level mediators were included to determine how much of the aforementioned

associations were due to children's experiences in the different types of classrooms. The indirect

command was used to test for mediation in Mplus. When predicting child outcomes, all focal

variables of interest were standardized to have a mean of 0 and standard deviation of 1; thus, all

reported covariate-adjusted estimates of children's kindergarten performance correspond to

effect sizes in terms of standard deviational units (adjusting for covariates).

Any evaluation of multi-grade education must acknowledge selection bias (see, Mason &

Burns, 1996); in other words, children are not randomly assigned to multi-grade and/or single-

grade classrooms, but rather, parents select whether to send their children to these

neighborhoods, schools, or classrooms, and thus factors that influence parents to choose one over

the other may also affect the child outcomes in question. To address selection bias, all analyses

accounted for children's incoming skills and behaviors (i.e., lagged dependent variable models),

which is one of the strongest adjustments for selection bias (National Institute of Child Health

and Human Development Early Child Care and Youth Development & Duncan, 2003). In

addition, propensity score matching methods (Rosenbaum & Rubin, 1983) were used to

minimize selection bias, whereby children were matched across groups so that they displayed

equal or similar characteristics at school entry (methodology discussed at greater length below).

Results

Prevalence and Characteristics of Multi-grade Kindergarten Classrooms

The first aim of this investigation was to document the prevalence and characteristics of

multi-grade kindergarten programs that combined pre-kindergarten and kindergarten classrooms

versus kindergarten-only classrooms. Estimates from ECLS-K: 2010-2011 cohort revealed that

200 children were enrolled in full-day multi-grade classrooms ($n_{classroom} = 50$; $n_{school} = 30$), which

when weighted to be nationally representative extrapolates to a little over 57,000 5-year-old

children across the nation (population estimates are generated based on the ECLS-K weights). In

contrast, roughly 2.76 million children attended full day kindergarten-only classrooms during the

2010-2011 school year ($n_{children} = 10,800; = n_{classrooms} = 2,360$; $n_{schools} = 680$); therefore, although

several thousand children were enrolled in classrooms that served both pre-kindergarteners and

kindergartners across the country, these multi-grade classrooms only served 2% of the 5-year-old

population. Descriptive analyses also revealed that 5-year-old children were more likely to attend

multi-grade classrooms when they lived in larger urban communities and when they lived in the

South (the significance of the group differences were estimated within a regression framework).

Moreover, parents who enrolled their children in multi-grade classrooms were, on average, a few

years older, more likely to be married, and more advantaged across indicators of socio-economic

status (e.g., education, employment, income). For other socio-demographic factors related to

families' selection into multi-grade versus kindergarten-only classrooms, see Table 1.

Not surprisingly, and as can be seen in Table 2, there were substantive differences across

the two types of classrooms in terms of the average classroom age composition. Approximately

70% of children in multi-grade kindergarten classrooms that served both pre-kindergartners and

kindergarteners were 4 years of age or younger, whereas 97% of children in kindergarten-only classrooms were 5 years of age or older.

Stark differences also emerged when looking at the descriptive differences in the classroom level processes (see left hand panel of Table 2). On average, 5-year-olds in multi-grade classrooms spent less time in whole group (5 hours less) and small group activities (1 hour less). In contrast, these children spent roughly 3 hours more per week in individual activities and over 6 hours more in child-selected activities. Five-year-olds in multi-grade classrooms also experienced less language and literacy (3 hours less) and math activities (0.5 hours less) as compared with their same-aged counterparts in kindergarten-only classrooms. Finally, a greater number of children's classmates in multi-grade classrooms were considered to be below grade level in academics at year's end (36% versus 17%). A number of these differences persisted when adjusting for other factors in the multivariate models (see right hand panel of Table 2).

Educational Outcomes of Children in Multi-grade Classrooms

Turning to research question 2, I next examined the associations between classroom type and children's educational outcomes (see Model 1 in Table 3). Results from these models revealed that children who attended multi-grade classrooms that combined pre-K and kindergarten demonstrated fewer gains in math and literacy skills throughout the school year, with effect sizes corresponding to 15 and 19% of a standard deviation, respectively. These disparities across classrooms were the equivalent of roughly 4 to 6.5 months of academic development (calculated by dividing the standardized difference in academic test scores by the regression slope of children's age; see Bradbury et al., 2011). Disparities in cognitive flexibility also emerged across classrooms, with children in multi-grade classrooms demonstrating fewer gains in cognitive flexibility (18% of a standard deviation) throughout the kindergarten year. Similar, albeit marginal, patterns emerged for children's working memory (10% of a standard

deviation, $p = .053$) and externalizing behavior problems (12% of a standard deviation, $p = .050$), but no significant differences were documented for children's internalizing problems or social skills. When taken together, these results indicate that children in multi-grade classrooms that combined both pre-K and kindergarten exhibited less optimal academic achievement, executive function, and externalizing behavior as compared with children in kindergarten-only classrooms.

Mediating Mechanisms of Multi-grade Kindergarten Education

Having established the disparities in children's early learning and development as a function of classroom type, the next goal of this investigation was to examine the processes underlying these differences. Accordingly, the classroom level factors were incorporated into each of the models to test for mediation. As can be seen in the Model 2 of Table 3, the negative associations between multi-grade classrooms and children's academic skills were attenuated by approximately half and were no longer statistically significant. Estimates of indirect effects revealed that this attenuation was statistically significant; that is, classroom-level processes accounted for a significant share of the difference in children's test scores across multi-grade and kindergarten-only classrooms, with effect sizes of 7-10% of a standard deviation. In contrast to children's academic achievement, the disparities in the other domains of school performance remained largely the same (see Table 3).

When looking at the specific classroom-level processes that accounted for this significant attenuation, results indicate that over 25% of the attenuation in the association between kindergarten type and children's math and literacy skills was attributed to the time children spent in child selected activities (see Table 3). Although not statistically significant (ps = .15-.18), roughly 10-15% of these differences in test scores was also attributed to the fact that children in multi-grade classrooms that enrolled both pre-kindergartners and kindergartners had a greater number of classmates who were below grade level in academics. In contrast to children's

academic performance, none of the mediators explained a significant share of the differences in

children's cognitive flexibility or any of the other outcomes of interest.

Robustness Checks

Considering that multi-grade classrooms that combined both pre-K and kindergarten were

more likely to be housed in private schools and employed less educated teachers (see Table 1),

ancillary analyses were estimated to determine whether the aforementioned associations were

conditioned on these two factors using interaction terms. Results from these analyses (available

from the author) revealed that the disparities in children's school success across multi-grade and

kindergarten-only classrooms were largely the same, regardless of school sector (public versus

private) and teachers' years of education (continuously measured). In light of the evidence that

the distribution of children's ages also has implications for child development (Blinded, 2015;

Moller et al., 2008) and considering that the majority of kindergarten-only classrooms had at

least one 6-year-old child—who were roughly a full year older than the children sampled in the

ECLS-K—supplementary analyses were estimated controlling for the proportion of 6 year olds

in each class. All results were quantitatively similar as those discussed above.

Finally, to address concerns regarding selection bias, propensity scores were estimated

using the psmatch2 function in the Stata program. Within each of the 50 imputed datasets, logit

models—which included the entire set of variables listed in Table 1—were estimated to gauge

the likelihood that children were enrolled in a multi-grade classroom (versus kindergarten-only).

The nearest neighbor method (with four matches) was used within a caliper of .05, which

resulted in match of roughly 180 children in multi-grade classrooms with approximately 480

children in kindergarten-only classrooms (sample sizes varied across imputations). The

replacement method was used in order to maximize the multi-grade kindergarten classrooms,

while a caliper width of .05 was implemented because this method has been shown to produce

more comparable comparison conditions (see Austin, 2011). Before propensity score matching, roughly 60% of the baseline characteristics were not balanced across the two conditions; as can be seen in Appendix Table 1, however, after employing propensity scores, there were no longer any significant differences across groups and the standardized differences were generally less than 10% of a standard deviation. As a further precaution, the overall balance of the matches was tested using a Hotelling test and the balance of the matched samples were checked within each quartile of the propensity scores, both of which also suggested that balance was largely achieved.

Having successfully achieved balance, the above models were replicated using the matched data in the Mplus program to test for the main effects of multi-grade education on children's school outcomes. In order to adjust for any potential remaining bias from measured characteristics, these models included all covariates (see also, Berger, Brooks-Gunn, Paxson, & Waldfogel, 2008; Coley & Lombardi, 2013). As can be seen in the Model 3 of Table 3, results from these analyses revealed much the same pattern: children who attended classrooms that combined pre-K and kindergarten performed less well in areas of literacy, mathematics, and cognitive flexibility as compared with children who attended kindergarten-only classrooms, with effect sizes ranging from 15-16% of a standard deviation. Although not statistically significant, the effect sizes for working memory and externalizing behavior remained comparable to the unmatched estimates. The only substantive difference that emerged across the unmatched and matched models was that after accounting for the classroom factors (see Model 4 of Table 3), there were no longer any differences in children's cognitive flexibility when estimating propensity score models (ES = 7% of a SD, *ns*), which was not the case when estimating models in the unmatched data (ES = 21% of a SD, *p* < .01)

Discussion

Although single-grade classrooms are the dominant method of educating children in the

U.S., the multi-grade model of education has long been an alternative philosophy that has been

implemented across the country (e.g., Katz, Evangelou, Hartman, 1990; Mason & Burns, 1996;

Veenman, 1995); yet, much of the empirical evidence behind this practice is fairly ambiguous.

Given the increased number of children attending kindergarten (Davis & Bauman, 2013), we

need to consider the implications of multi-grade education when it is implemented during the

transition to school, which has long-term implications for children's learning and development

(Duncan et al., 2007; Entwisle & Alexander, 1989; Jones et al., 2015). Such inquiry is especially

important in light of the "academization" of kindergarten (Bassok et al., 2016). Accordingly, the

current investigation sought to contribute to this literature by conducting secondary data analysis

of the ECLS-K class of 2010-2011 to answer three questions regarding: (1) the prevalence and

characteristics of multi-grade classrooms that combine pre-K and kindergarten classrooms ; (2)

the educational outcomes of kindergarteners in these classrooms; and (3) the mechanisms

through which multi-grade classrooms affect 5-year-old's educational outcomes. The results of

this investigation have two take home messages.

To begin, only a small share of the overall kindergarten population in the U.S. attends

classrooms that also serve pre-kindergarteners; however, at the population level, these estimates

translate to roughly 57,000 children, or 2% of children, which is smaller than the share of

children in multi-grade classrooms at older ages (5%). In contrast to social learning and

cognitive theories of child development (Bandura, 1986; Vygostky, 1978), the results from this

investigation revealed that 5-year-old children who were enrolled in classrooms that served both

pre-kindergarteners and kindergarteners fared less well academically as compared with those

who attended kindergarten only classrooms. These differences in children's academic skills

corresponded with 4 to 6.5 months of academic development. Children in multi-grade

classrooms also demonstrated less optimal executive functioning than did 5-year-olds who

attended kindergarten-only classrooms, but similar to prior studies in this area of work (Ansari et

al., 2016; Thomas, 2012; Veenman, 1995), children in multi-grade classrooms were not

consistently performing any better (or worse) than their classmates in areas of social-behavior.

Though prior studies suggest that the effects of multi-grade education are mixed (e.g.,

Mariano & Kirby, 2009; Thomas, 2012), much of this literature has sampled older children

during first or second grade and beyond. This lack of empirical attention on the transition to

school is notable as the skills children demonstrate in kindergarten are predictive of their short-

and long-term school success as well as their long-term well-being through the transition to

adulthood (Duncan et al., 2007; Entwisle & Alexander, 1989; Jones et al., 2015). For these

reasons, future studies should consider the relative age of children to determine whether the

effects of multi-grade classrooms change as children get older. In fact, recent analyses of

preschool programs reveal much the same pattern as those reported here: older children who

were enrolled in classrooms with a greater number of younger children performed less well

academically as compared with older children in preschool classrooms with fewer younger

children (Ansari et al.,, 2016; Moller et al., 2008). Therefore, the implementation of multi-grade

(and mixed-age) classrooms during early childhood and the transition to school requires greater

scrutiny—just because children in multi-grade classrooms do no better or worse than children in

single-grade classrooms during first grade and beyond (e.g., Thomas, 2012; Veenman, 1995),

does not mean that such practices produce no differences when implemented at kindergarten.

When taken together, the results of this study are in line with the findings reported by Mariano

and Kirby (2009), who found that multi-grade classrooms were less conducive for children's

academic achievement; however, the effect sizes reported herein were somewhat larger (10-20%

of a standard deviation versus 10% of a standard deviation). The effect sizes reported as part of

this study were also larger as compared with those documented by Thomas (2012) who examined multi-grade classrooms implemented in first grade (0-6% of a standard deviation).

Moving to the second take home message, the reasons why multi-grade classrooms appear to have a deleterious effect on children's educational outcomes have been understudied, but this study was able to identify meditational processes for their associations with kindergartener's development. The results from this investigation not only demonstrate that the experiences of children in these classrooms were qualitatively different—children in multi-grade classrooms that served both pre-kindergartners and kindergartners experienced significantly less literacy stimulation and spent less time in teacher-directed activities—but these classroom-level processes mediated the negative associations that were documented between multi-grade classrooms and children's academic achievement. Thus, one of the underlying explanations for why children in multi-grade classrooms performed less well academically was because they received less teacher-directed instruction. It is important to interpret these mediational findings in the context of the existing literature on classroom pedagogy, which also suggest that more time spent in quality didactic teacher-directed instruction facilitates children's early academic achievement (Barnett, 2011; Mashburn et al., 2008; Pianta, Belsky, Vandergrift, Houts, & Morrison, 2008; Stipek, Feiler, Daniels, & Milburn, 1995). At the same time, however, more time spent in didactic instruction has been found to result in less optimal social-behavioral development among young children (Stipek, et al., 1995).

Nonetheless, when taken as a whole, these meditational analyses indicate that there are, in fact, "indirect" pathways between multi-grade education and children's early academic learning. From a practical perspective, these indirect pathways may prove to be malleable targets for intervention, which can be a first step in addressing the long-standing concerns of multi-grade classrooms (Mason & Burns, 1996). These findings are especially important when

considering that some multi-grade programs—and by extension mixed-age programs—are implemented due to economic and logistical constraints and, therefore, separately serving 4- and 5-year-old children is likely to be challenging for some kindergarten programs.

Despite these potential mechanisms that underlie the associations between multi-grade classrooms and children's academic achievement, the mechanisms for children's executive function were unclear. Although this study could not uncover these processes, one might further speculate that classroom management and quality, which prior studies have found to be positively associated with children's executive function (Rimm-Kaufman et al., 2009; Weiland, Ulvestad, Sachs, & Yoshikawa, 2013), are two alternative pathways for the documented associations. Unfortunately, the ECLS-K data did not have indicators of classroom quality or specific information on what teachers were doing in the classroom during the different types of activities to test such hypotheses. Considering the fact that children's executive functioning rapidly evolves during this period, continued work is necessary to explore the pathways through which multi-grade classrooms may affect children's development of executive function skills.

As with any study, the results of this study need to be interpreted in light of its limitations, beyond those discussed above. Primarily, the ECLS-K class of 2010-2011 included a nationally representative sample of kindergarteners—not pre-kindergarteners—and, thus, these data cannot (and do not) speak to the benefits of multi-grade education for the preschool-age children who were enrolled in these classrooms. Whether younger children benefit from having older children in the classroom remains contested with some scholars documenting positive effects (Guo et al., 2014) and others documenting null or negative associations (Ansari et al., 2016; Bell et al., 2013; Moller et al., 2008; Thomas, 2012; Veenman, 1995) and, therefore, remains a topic for future research. It should be kept in mind, however, that even if the younger

children were to benefit from having kindergarteners in the classroom, these data suggest that it would be at the expense of the older children's academic achievement and executive functioning.

Second, although several precautions were taken to address potential selection bias (e.g., lagged dependent variable analyses and propensity score matching), the results reported herein need to be interpreted with caution because children were not randomly assigned to multi-grade and kindergarten-only classrooms. Additional analytical strategies (e.g., random assignment, instrumental variables) must be used to build on this correlational evidence to test for causal associations; even so, it is encouraging that the outcomes associated with multi-grade classrooms were largely the same across model specifications. Moreover, although the sample provided enough statistical power to detect meaningful differences, the small sample of children in multi-grade classrooms limited the types of analyses that could be conducted. Future studies, therefore, should consider oversampling children in multi-grade classrooms, which, in turn, will allow for a stronger assessment of the underlying mechanisms for these documented associations. In doing so, future studies can also consider potential moderating variables to determine under what context or conditions these effects are amplified (or attenuated). Relatedly, future studies should inspect of the long-term implications of multi- versus single-grade education and would greatly benefit from stronger and more detailed measures of classroom processes, which would allow for a better evaluation of the degree of difference across classrooms. Finally, closer attention must be paid to variation within multi-grade classrooms in order to determine whether, and why, some multi-grade programs are more successful than others. For example, understanding whether programs were implemented for pedagogical or logistical reasons is necessary because it is likely that pedagogical (as compared with logistical) implementation will account for distinct outcomes, whereas logistical implementation may indicate a lack of training.

In sum, this study provided a large-scale national portrait of multi-grade education during the kindergarten year that can be built on by more intensive multi-method community-based approaches in the future. The results of this study also provided some of the first evidence to suggest that, at the national level, 5-year-olds who attended multi-grade kindergarten classrooms with pre-kindergartners were performing less well academically as compared with 5-year-olds who attended kindergarten-only classrooms. Classroom-level processes largely explained these differences. If future studies can address the limitations of this study and replicate the findings reported herein, then this research would have potential developmental and policy implications for children's learning during the transition to school. Specifically, with the small number of programs that combine pre-kindergarten and kindergarten classrooms in the U.S., these results suggest that, when possible, their implementation may need to be re-evaluated.

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Table 1.
Sample descriptives across kindergarten-only and multi-grade classrooms.

	Kindergarten-only	Multi-grade	Sig. group difference
Child/household characteristics			
Age at kindergarten entry	66.26 (4.64)	63.79 (5.70)	***
Child male	0.52	0.57	
Child White	0.51	0.54	
Child Black	0.16	0.14	
Child Latino	0.24	0.20	
Child Asian/Other	0.09	0.13	†
English home language	0.84	0.93	***
First time kindergartener	0.94	0.92	
Child diagnosed with disability	0.21	0.23	
Beginning of year skills			
Math	29.87 (10.71)	31.72 (10.05)	*
Reading	36.98 (9.19)	39.79 (11.15)	***
Working memory	432.00 (29.97)	437.22 (29.71)	*
Cognitive flexibility	14.24 (3.24)	14.18 (3.27)	
Attentional control	3.87 (0.89)	3.98 (0.78)	
Externalizing	1.63 (0.64)	1.62 (0.60)	
Internalizing	1.47 (0.50)	1.44 (0.49)	
Social skills	2.97 (0.64)	3.03 (0.59)	
Parent education	13.55 (2.61)	15.62 (2.40)	***
Parent age	33.51 (6.97)	36.51 (6.29)	***
Parents' married	0.64	0.76	***
Children in house	2.51 (1.15)	2.22 (0.96)	***
Mom employed full time	0.44	0.56	***
Mom employed part time	0.20	0.21	
Mom unemployed	0.37	0.24	***
Household income	9.57 (5.58)	13.56 (5.24)	***
School/class characteristics			
Class size	20.41 (4.95)	16.19 (9.35)	***
Teacher experience	14.19 (9.64)	16.37 (10.76)	***
Teacher years of education	16.95 (1.12)	15.92 (1.34)	***
Teacher change	0.07	0.08	
Public school	0.89	0.30	***
Percent minority	0.47	0.48	
Percent eligible for free/reduced lunch	0.48	0.17	***
School size	513.81 (236.13)	267.52 (238.53)	***
Northeast	0.13	0.19	*
Midwest	0.24	0.07	***
South	0.44	0.57	***
West	0.19	0.18	
City	0.33	0.45	***
Suburb	0.29	0.40	***

Town	0.12	0.03	***
Rural	0.26	0.12	***
End of kindergarten outcomes			
Math	43.12 (11.36)	43.21 (11.31)	
Reading	49.53 (11.33)	49.89 (13.25)	
Working memory	449.65 (30.21)	451.75 (28.59)	
Cognitive flexibility	15.18 (2.71)	14.93 (2.98)	
Attentional control	4.03 (0.89)	4.05 (0.79)	
Externalizing	1.66 (0.65)	1.78 (0.63)	*
Internalizing	1.53 (0.50)	1.57 (0.50)	
Social skills	3.12 (0.65)	3.14 (0.65)	
Child level sample size	10,800	200	
Classroom level sample size	2,360	50	
School level sample size	680	30	
Population estimate	2,760,200	57,000	

Notes. Proportions might not sum to 1.00 due to rounding.
*** $p < .01$. ** $p < .01$. * $p < .05$. † $p < .10$

Table 2.

Weighted bivariate and multivariate differences in classroom level processes.

	Bivariate differences, *Mean (SD)*					Multivariate differences [a]		
	Kindergarten-only	Multi-grade	Diff.	e.s.		*b* [95% CI]	e.s.	
Classroom age composition								
% 3 years of age	0.00	0.26	0.26	4.72	***	—	—	—
% 4 years of age	0.03	0.43	0.40	3.77	***	—	—	—
% 5 years of age	0.82	0.28	-0.54	-3.03	***	—	—	—
% 6 years of age or greater	0.15	0.02	-0.13	-0.84	***	—	—	—
Hours per week spent in…								
Whole group activities	11.32 (4.73)	6.60 (4.88)	-4.72	-0.99	***	-4.91 [-6.62, -3.19]	-1.03	***
Small group activities	7.53 (4.02)	6.76 (4.72)	-0.77	-0.19	**	-0.07 [-1.47, 1.33]	-0.02	
Individual activities	4.65 (2.98)	7.52 (5.81)	2.87	0.93	***	2.87 [0.81, 4.93]	0.93	**
Child selected activities	4.09 (2.53)	10.21 (6.04)	6.11	2.19	***	5.60 [3.52, 7.68]	2.01	***
Language arts activities	10.25 (3.74)	7.32 (4.16)	-2.93	-0.77	***	-1.30 [-2.67, 0.06]	-0.34	†
Math activities	6.35 (2.74)	5.90 (3.70)	-0.44	-0.16	*	0.12 [-1.08, 1.31]	0.04	
Dealing with misbehavior	3.83 (3.32)	4.04 (3.27)	0.21	0.06		0.47 [-0.70, 1.64]	0.14	
Overall class behavior	3.41 (0.88)	3.46 (0.75)	0.05	0.06		-0.03 [-0.30, 0.24]	-0.03	
% of children below grade level	0.17	0.36	0.19	0.76	***	0.20 [-0.01, 0.40]	0.80	†

Notes. [a] The multivariate models included clustered standard errors at the school level and adjusted for the baseline factors listed in Table 1. e.s. = effect size in standard deviation units. *** $p < .01$. ** $p < .01$. * $p < .05$. † $p < .10$

Table 3.

Results from unmatched and matched models predicting child outcomes as a function of multi-grade versus kindergarten-only classrooms.

	Reading	Math	Working memory	Cognitive flexibility	Externalizing	Internalizing	Attentional control	Social skills
Model 1: No mediators, unmatched sample								
Multi-grade (kindergarten-only)	-0.19 **	-0.15 *	-0.10 †	-0.18 **	0.12 †	0.16	0.01	0.04
	[-0.31, -0.07]	[-0.27, -0.04]	[-0.20, 0.00]	[-0.32, -0.05]	[0.00, 0.23]	[-0.03, 0.36]	[-0.09, 0.11]	[-0.12, 0.20]
Model 2: With mediators, unmatched sample								
Multi-grade (kindergarten-only)	-0.09	-0.08	-0.06	-0.21 **	0.10	0.11	0.03	0.06
	[-0.24, 0.06]	[-0.21, 0.05]	[-0.16, 0.04]	[-0.35, -0.06]	[-0.02, 0.23]	[-0.09, 0.30]	[-0.06, 0.12]	[-0.10, 0.23]
Indirect effect via…								
Whole group activities	0.00	0.01	0.00	0.02	-0.01	0.01	0.01	0.01
	[-0.02, 0.02]	[-0.01, 0.03]	[-0.02, 0.02]	[-0.01, 0.05]	[-0.02, 0.01]	[-0.02, 0.04]	[-0.01, 0.03]	[-0.02, 0.03]
Small group activities	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]	[-0.01, 0.01]	[-0.00, 0.00]	[-0.00, 0.00]	[-0.01, 0.01]	[-0.00, 0.00]	[-0.01, 0.01]
Individual activities	-0.02	-0.01	0.00	0.00	0.01	0.02	-0.01	-0.02
	[-0.04, 0.00]	[-0.03, 0.01]	[0.02, 0.02]	[-0.02, 0.03]	[-0.01, 0.02]	[-0.01, 0.04]	[-0.03, 0.01]	[-0.05, 0.01]
Child selected activities	-0.05 *	-0.04 *	-0.02	0.03	0.01	0.02	-0.02	0.01
	[-0.10, -0.01]	[-0.08, -0.01]	[-0.06, 0.02]	[-0.01 08]	[-0.02, 0.05]	[-0.03, 0.07]	[-0.05, 0.02]	[-0.03, 0.05]
Language arts activities	-0.01	-0.00	-0.01	-0.01	0.00	-0.00	-0.00	-0.01
	[-0.02, 0.00]	[-0.01, 0.01]	[-0.02, 0.01]	[-0.02, 0.01]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.03, 0.00]
Math activities	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[-0.00, 0.00]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.00, 0.00]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.00, 0.00]
Dealing with misbehavior	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01
	[-0.01, 0.00]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.02]
Overall class behavior	-0.00	-0.00	-0.00	0.00	0.00	0.00	-0.00	-0.00
	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.00]	[-0.01, 0.00]	[-0.02, 0.03]	[-0.01, 0.01]	[-0.02, 0.02]	[-0.02, 0.02]
% of children below grade level	-0.02	-0.02	-0.01	-0.02	-0.00	0.01	-0.01	-0.01
	[-0.04, 0.01]	[-0.04, 0.01]	[-0.03, 0.01]	[-0.05, 0.01]	[-0.01, 0.01]	[-0.01, 0.03]	[-0.03, 0.01]	[-0.03, 0.02]
Total indirect effect	-0.10 ***	-0.07 **	-0.04	0.03	0.01	0.06 †	-0.03	-0.02
	[-0.16, -0.04]	[-0.12, -0.02]	[-0.09, 0.01]	[-0.03, 0.08]	[-0.04, 0.07]	[-0.00, 0.12]	[-0.08, 0.03]	[-0.08, 0.04]
Model 3: No mediators, matched sample								
Multi-grade (kindergarten-only)	-0.16 **	-0.15 **	-0.08	-0.15 *	0.12 †	0.13	-0.03	-0.03
	[-0.28, -0.05]	[-0.26, -0.04]	[-0.21, 0.04]	[-0.30, -0.01]	[-0.02, 0.27]	[-0.07, 0.33]	[-0.15, 0.010]	[-0.19, 0.13]
Model 4: With mediators, matched sample								
Multi-grade (kindergarten-only)	-0.11	-0.05	0.02	-0.07	0.17 †	0.10	-0.07	-0.05
	[-0.28, 0.05]	[-0.20, 0.10]	[-0.16, 0.20]	[-0.24, 0.11]	[-0.01, 0.34]	[-0.13, 0.33]	[-0.26, 0.11]	[-0.27, 0.17]

Note. All outcomes and mediators have been standardized to have a mean of 0 and standard deviation of 1 and, thus, all estimates in this table correspond to effect sizes (i.e., standard deviation units). Estimates in brackets correspond to 95% confidence intervals.

*** $p < .01$. ** $p < .01$. * $p < .05$. † $p < .10$