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Head Start program quality: Examination of classroom quality and parent involvement in predicting children's vocabulary, literacy, and mathematics achievement trajectories☆

Xiaoli Wen[a,*], Rebecca J. Bulotsky-Shearer[b], Debbie L. Hahs-Vaughn[c], Jon Korfmacher[d]

[a] National-Louis University, 122 South Michigan Avenue, Chicago, IL 60603, United States
[b] University of Miami, United States
[c] University of Central Florida, United States
[d] Erikson Institute, United States

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ABSTRACT

Guided by a developmental–ecological framework and Head Start's two-generational approach, this study examined two dimensions of Head Start program quality, classroom quality and parent involvement and their unique and interactive contribution to children's vocabulary, literacy, and mathematics skills growth from the beginning of Head Start through the end of first grade. The study is a secondary data analysis of FACES 1997, a national descriptive study of Head Start children, families, and programs. The piecewise 3-level growth curve model suggested that Head Start children demonstrated positive academic growth trajectories over time, with vocabulary and literacy skills showing more rapid growth in Head Start years than in later grades. Younger children consistently showed more rapid growth than older children, especially during kindergarten and first grade. Head Start classroom quality and parent involvement uniquely and interactively predicted children's academic growth across time, but in rather complex ways.

Children living in poverty face disproportional threats to their ability to meet the social and academic demands of elementary school (Bornstein & Bradley, 2003; Lee & Burkam, 2002). Quality early childhood educational experiences are identified as important protective factors for low-income children (Bowman, Donovan, & Burns, 2001; Peisner-Feinberg et al., 2001). As the nation's largest, most comprehensive response to the needs of low-income preschool children, Head Start is in the unique position to provide quality early educational experiences that can foster social and academic readiness skills.

Researchers have begun to conceptualize early educational program quality as a multi-dimensional construct, influenced in a transactional way by classroom dynamics, classroom and program structure, staff characteristics, parent involvement, and other contextual factors (Lambert, Abbott-Shim, & Sibley, 2005). As a two-generational program that focuses not only on the health and well-being of children but parents as well, Head Start recognizes the important contribution of multiple influences on children's development and emphasizes multiple indicators of a quality program (Head Start Performance Standards, U.S. DHHS, 1996). In this study, we focus on two critical dimensions of program quality that are highlighted in the Head Start Performance Standards: classroom quality and parent involvement in children's early care and education. We examine how these two dimensions predict children's academic growth from Head Start through their transition into kindergarten and first grade. The data were drawn from the Family and Child Experiences Survey (FACES 1997; U.S. DHHS, 2005), a national descriptive study of Head Start programs.

Within a developmental–ecological framework, the early childhood classroom and family environment are conceptualized as important proximal microsystem contexts that most directly influence young children's early development and learning (Bronfenbrenner & Morris, 1998). Research suggests that positive effects are most likely when experiences in the home and school are mutually supportive (e.g., Votruba-Drzal, Coley, & Chase-Lansdale, 2004). However, there is not much empirical research focused explicitly on how the home and classroom contexts work together to support children's academic trajectories. Existing research focuses primarily on one set of factors, either at the family or classroom level, rather than examining both simultaneously. Even when researchers have included both home and classroom

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* Corresponding author. Tel.: +1 312 261 3160; fax: +1 312 261 3160.
E-mail address: xiaoli.wen@nl.edu (X. Wen).

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factors to predict children's academic growth, the interactions between home and classroom variables are often not investigated (e.g., Hindman, Skibbe, Miller, & Zimmerman, 2010). Therefore, the current study aimed to examine the unique and interactive effects of Head Start classroom quality and parent involvement on children's academic development over time.

1. Contribution of classroom quality to academic growth

Research in early childhood education program quality has focused largely on indicators of both classroom structure (e.g., learning environment) and process (e.g., teacher–child interactions). Empirical evidence suggests that structural quality features of preschool classrooms promote early language, literacy, and mathematics skills; these include access to a variety of developmentally appropriate learning materials, as well as daily schedules and activities that balance child-centered learning and didactic instruction (e.g., Connor, Morrison, & Slominski, 2006; Wishard, Shivers, Howes, & Ritchie, 2003). Research also underscores the key role of teacher sensitivity, responsiveness, and positive teacher–child interactions in supporting children's language, literacy, prosocial behavior, and emotional development (e.g., Howes et al., 2008; LoCasale-Crouch et al., 2007; Mashburn, 2008).

There is a large body of research documenting the contribution of early childhood classroom quality to children's early academic success, including the studies that have been conducted with large national samples of child care facilities (e.g., NICHD ECCRN, 2005a, 2005b), state funded pre-kindergartens (e.g., Burchinal et al., 2008; Magnuson, Ruhm, & Waldfogel, 2007), and Head Start programs (e.g., Head Start Impact Study; U.S. DHHS, 2010). Longitudinal studies also suggest that the effects of early education quality persist. Children who experience higher-quality preschool classrooms enter school with better language, mathematics, and reading skills, and these benefits continue into the early grades (e.g., DiPerna, Lei, & Reid, 2007; Pianta, La Paro, Payne, Cox, & Bradley, 2002). In addition, the effects of high-quality early childhood education are most pronounced for children from low-income families or families with other social risk factors (Magnuson, Meyers, Ruhm, & Waldfogel, 2004; Mashburn et al., 2008).

1.1. *Contribution of parent school and home involvement to academic growth*

Parent involvement has been endorsed as a fundamental component of successful early intervention and preschool programming (Weiss, Caspe, & Lopez, 2006). Head Start is a pioneering program emphasizing parent involvement, which has been a significant cornerstone of the program since its beginnings (Zigler & Styfco, 2000). Parent involvement has been conceptualized as a multidimensional construct, including both involvement within the school and the home contexts (Fantuzzo, Tighe, & Childs, 2000).

Program activity participation, such as volunteering at school and participating in parent–teacher conferences, has been the most straightforward indication of parent involvement with early education programs (Hill & Taylor, 2004). Miedel and Reynolds (1999) studied the Chicago Child-Parent Center program, an early intervention for disadvantaged families, and found that greater parent participation in preschool and kindergarten activities was associated with higher reading achievement, lower rates of grade retention, and fewer years in special education when children were in eighth grade. Lamb-Parker et al. (1997) also reported significant positive associations between the number of Head Start parents' volunteer hours and attendance at program workshops and parent and teacher ratings of children's academic motivation, social competence, and school readiness. Other research also supports the association between parents' school involvement and children's literacy, mathematics, and social skills in early elementary school (Dearing, Kreider, Simpkins, & Weiss, 2006; Hill & Craft, 2003).

In addition to school involvement, parental engagement with children's learning at home has been identified as another important dimension of parent involvement (Fantuzzo et al., 2000). It is worth acknowledging, however, that this construct has been identified as an indicator of parenting quality in some studies (e.g., Brotman et al., 2011). In the current study, the measure of home involvement specifically focuses on parent's home learning activities with their child. Home-based involvement has been shown to be one of the most significant predictors of children's academic achievement (e.g., Halgunseth, Peterson, Stark, & Moodie, 2009). For example, parent–child interaction and access to literacy materials were associated with higher emergent literacy skills for Head Start children (e.g., Harris & Goodall, 2008). One study with low-income kindergarten children and their families found that parents who actively promoted learning in home, had direct and regular contact with school, and experienced fewer barriers to involvement had children who demonstrated positive engagement with their peers, adults, and learning (McWayne, Hampton, Fantuzzo, Cohen, & Sekino, 2004). Bradley, Corwyn, Burchinal, McAdoo, and Garcia Coll (2001) further confirmed that home learning experiences and parental responsiveness significantly predicted development in early motor and social development, language competence, and academic achievement for an ethnically diverse sample of children.

Interestingly, one study with a sample of predominantly African American, urban Head Start children found that parents' home-based involvement was the strongest predictor of children's outcomes relative to school-based involvement or parent–teacher communication; further, when the effects of school and home-based involvement were considered simultaneously, school-based involvement no longer significantly predicted children's school readiness outcomes (Fantuzzo, McWayne, Perry, & Childs, 2004). However, a recent study with a partial sample (4-year-old children only) of the Head Start FACES 1997 study did not find significant effects of either parent's home or school involvement on children's literacy and mathematics skill growth (Hindman et al., 2010). More investigations with both dimensions of parent involvement are needed to more fully understand these findings for Head Start and other pre-kindergarten populations.

1.2. *Interactions between classroom quality and parent involvement*

From an ecological perspective, we would expect that positive child outcomes are most likely when the early childhood classroom and family environment both encourage and support early learning, that is, when each environment complements the other (Magnuson et al., 2004; Votruba-Drzal et al., 2004). If we translate this interactive relationship between family and school factors into our study hypotheses, we would expect to see that in higher-quality Head Start classrooms, positive associations between parent involvement and children's academic growth would be stronger than would be observed for children participating in lower-quality classrooms.

Often, families facing economic constraints are limited in the quantity and quality of home learning experiences they can provide for their children (Votruba-Drzal, 2003). Research suggests that parents living in poverty are more likely to experience depression, and as a consequence may be less sensitive and responsive to their child's needs (Evans, 2004; McLoyd, Jayaratne, Ceballo, & Borquez, 1994). Poor children are also exposed to fewer academically and cognitively stimulating activities in the home. For example, poor parents spend less time reading to their children, less time talking with them, and less time visiting museums and libraries with them (Bradley, Burchinal, & Casey, 2001; Coley, 2002).

For children from economically disadvantaged families, an enriched learning environment provided by a high-quality educational program may confer substantial learning benefits (Magnuson et al., 2004; McCartney, Dearing, Taylor, & Bub, 2007). In other words, a high-quality program experience may serve as a protective factor for low-income children and mitigate the negative effects of poverty on early learning and development (Camilli, Vargas, Ryan, & Barnett, 2010). Indeed, this argument was one of the original motivations for the creation of early childhood intervention programs such as Head Start. Many studies have shown that preschool quality has stronger positive effects among children who experience social and economic risks (e.g., Burchinal, Ramey, Reid, & Jaccard, 1995; Votruba-Drzal et al., 2004). In this study, we hypothesize that the benefits of a high-quality Head Start program experience are greater for children whose parents were less involved with them at home and at school. Therefore, being in a high-quality classroom may buffer the potential negative association between low parent involvement and child academic growth, so that Head Start children would still maintain a reasonable rate of growth.

Given the consistent finding that family characteristics such as income, maternal education, and parent involvement are among the strongest predictors of children's academic skills, even among these children who experienced full-time non-parental child care (Burchinal, Peisner-Feinberg, Pianta, & Howes, 2002; Downer & Pianta, 2006; NICHD ECCRN & Duncan, 2003), it is imperative to examine how family factors, such as parent involvement, interact with preschool classroom quality to support low-income children's academic skill growth.

There have been few studies that have examined the interactions among child, family, and classroom characteristics and preschool children's early academic and cognitive skills, particularly when examining change over time in these skills. For example, Burchinal et al. (2002) found that having a close teacher–child relationship (one aspect of classroom process quality) buffered the negative effects of authoritarian parenting on children's reading competence. This suggests a compensatory effect of a high-quality classroom experience for children who experienced authoritarian parenting, although this study did not directly measure parent involvement. Another study conducted with Head Start parents and teachers showed that classroom quality was a strong predictor of parent involvement in their child's Head Start program (Castro, Bryant, Peisner-Feinberg, & Skinner, 2004). In other words, in higher-quality classrooms, parents were more likely to be involved in their children's Head Start experiences, although this study did not link either construct to children's outcomes. These findings point to the need for more research to unpack the complex interrelationships among Head Start classroom quality and parent involvement and their associations with children's academic trajectories. This research will enhance our understanding of the underlying mechanisms by which early interventions such as Head Start can promote positive development in high-risk children.

1.3. Predicting academic growth using FACES 1997

The Head Start Family and Child Experiences Survey (FACES) is a national descriptive study of Head Start programs, children, and their families. Four cohorts of FACES have been fielded to date–FACES 1997, 2000, 2003 and 2006. Although the 1997 cohort data were collected over a decade ago, it is the only study that followed children into first grade (the other cohorts tracked children only into kindergarten) and it best fits the purpose of our current study of examining children's academic growth over time.

Numerous experimental and observational studies document the short-term and long-term benefits of attending high-quality preschools (e.g., Gormley, Gayer, Phillips, & Dawson, 2005; Schweinhart et al., 2005). However, most studies assumed a linear trajectory in investigating children's academic developmental growth (e.g., Burchinal et al., 2002). Given the fact that many Head Start graduates were enrolled in public elementary schools, it is reasonable to suspect that children might have different growth trajectories within Head Start in contrast to later school years due to potential differences in the classroom quality between Head Start and public schools. In fact, some studies have suggested a "fade-out" effect in cognitive gains when children transition from high-quality intervention programs into the public school system where a large variation in teaching quality exists (Brooks-Gunn, 2003; Currie & Thomas, 2000). Therefore, this current study investigated whether Head Start children demonstrated distinctive growth at this critical transition from Head Start to formal schooling, and how parent involvement and classroom quality measured during Head Start predicted these growth trajectories.

One unique characteristic of the FACES 1997 sample is that it includes two age groups of Head Start children: 3- and 4-year-old children (with similar sample sizes for each group). This sample grants us an opportunity to compare and contrast whether these two groups of children exhibit different growth patterns. In this sample, 3-year-old children experienced Head Start at an earlier age and for a longer period of time (i.e., two years) in comparison to 4-year-old children. Experimental studies of early intervention programs suggest that the duration and timing of exposure to an intervention relate to children's outcomes–the earlier and longer the intervention, the more favorable the outcomes (e.g., Campbell & Ramey, 1995; Reynolds, 1994). Although the FACES study is descriptive, we took advantage of its unique sample composition to compare children's growth in the two age groups. A recent study by Hindman et al. (2010) using FACES 1997 also examined Head Start children's academic growth, but included only the 4-year-old sample, and found that this particular age group of children demonstrated positive growth over time. Our study extends this earlier study by examining academic growth trajectories for both 3- and 4-year-old children in this sample.

2. Research questions

The current study is a secondary analysis of data from the FACES 1997 study. The purpose of the present study was to examine the unique and interactive contribution of classroom quality and parent involvement to children's academic growth, across the critical transition from preschool to kindergarten and first grade. Two research questions were addressed: (a) What is the nature of children's early vocabulary, literacy, and mathematics achievement trajectories from Head Start through first grade? We hypothesized an overall positive growth trajectory, with more rapid growth in Head Start than in kindergarten and first grade and more rapid growth for 3-year-old children than for 4-year-old children. (b) How do parent involvement and Head Start classroom quality predict children's vocabulary, literacy, and mathematics achievement across the transition from Head Start through first grade? We hypothesized that both parent involvement and classroom quality would have unique and interactive effects on children's academic growth over time. High-quality classroom experiences would enhance the positive association between high-levels of parent involvement and children's academic growth and buffer the negative association between low-levels of parent involvement and children's academic growth.

3. Method

3.1. Data source—FACES 1997

In 1997, the Head Start Bureau launched the Family and Child Experience Survey (FACES), which is a large-scale nationally representative descriptive study of the characteristics, experiences, and outcomes of Head Start programs, children, and their families (U.S. DHHS, 2005). The sample of children and families was stratified by region of the country, Metropolitan Statistical Area status (urban or rural), and percentage of minority families in the program (above or below 50%). The sample included both 3- and 4-year-old children who were newly enrolled in Head Start in the fall of 1997. The study gathered comprehensive data on the cognitive, social, emotional, and physical development of Head Start children, characteristics and well-being of the Head Start families, quality of Head Start classrooms, and characteristics of Head Start programs and staff. Data were collected through direct child assessment, parent interview, classroom observations, and teacher report.

The data collection phases occurred in Fall 1997 (wave one, initial assessments for all children), Spring 1998 (wave two, assessment of children who continued with Head Start and those completing the program), Spring 1999 (wave three, assessments of Head Start children completing the program and kindergarten follow-up of children who completed Head Start in Spring 1998), Spring 2000 (wave four, kindergarten follow-up of children who completed Head Start in Spring 1999 and first-grade follow-up of children who completed Head Start in Spring 1998), and Spring 2001 (wave five, first-grade follow-up of children who completed Head Start in Spring 1999). Additional details on the methodology of the FACES 1997 study can be found in its technical report (U.S. DHHS, 2005). In summary, all children were assessed during the beginning of their first year in Head Start, spring of their last year of Head Start, spring of kindergarten, and spring of first grade. One additional assessment was conducted for children who received two years of Head Start and this was conducted during the spring of their second year of Head Start.

4. Participants

The current study used the longitudinal dataset of the FACES 1997 to address the research questions. The longitudinal sample consisted of 1968 children, from 31 Head Start programs and 484 classrooms. More than two hundred children who were tested in Spanish (because their primary language was Spanish) were not included in the present study. Among the remaining sample (N = 1640), forty-two percent of children were 3-years old (58% were 4-years old) when they first enrolled in Head Start. Approximately 51% of children were boys. The average age of the sample at the initial assessment was 49 months (SD = 6; ranged from 36 to 68 months). Seventeen percent of children had identified disabilities. About 39% of the sample children were African-American, 30% were Hispanic, and 24% were white. Thirty-two percent of children were from language-minority families (speaking another language in addition to English), however, they were determined by the language screening to be proficient enough in English to be assessed using the English measures (U.S. DHHS, 2005). Forty-three percent of children lived in mother-and-father household, and 29% were receiving welfare support. About 69% of children were in Head Start programs that were located in urban settings. About 27% of main caregivers (of all main caregivers, 88% were mothers, 5% fathers, and 4% grandmothers) did not finish high school, 36% held a high school diploma or GED, 28% had some college, and the rest had an associate's degree or higher. Over 72% of the children lived in households below the federal poverty line, and approximately 47% of caregivers were not employed at the time of the study. The average age of primary caregivers was 30 years (SD = 8, ranged from 17 to 79 years).

5. Measures

5.1. Child academic outcomes

The current study focuses on children's receptive vocabulary, literacy skills, and mathematic skills as these measures were repeated across each wave of data collection. The Peabody Picture Vocabulary Test (3rd edition, Dunn & Dunn, 1997) assessed children's understanding of the meaning of words. Children were asked to say the number or point to the one of four pictures that best showed the meaning of a word that is said aloud by the assessor. The test has established age norms based on a national sample of 2725 children and adults. The published internal consistency reliability coefficients are reported ranging from .92 to .98, with test–retest reliability ranging from .91 to .94 (Dunn & Dunn, 1997). In the FACES 1997 sample, internal consistency reliability was .96 or greater. The one-parameter item response theory (IRT) W score of the PPVT test available in FACES 1997 dataset was used in the analyses. IRT models are based on a mathematical function related to the probability of answering an item correctly and account for both item difficulty and the ability of the test taker. The W score derived from these analyses allowed for more precise calculation of individual growth over time in the longitudinal analysis (as compared to using a raw or standard score; Hambleton, Swaminathan, & Rogers, 1991), and the W scores were highly correlated with the standard scores (.92–.97 across all waves of data).

The Woodcock-Johnson Battery consists of a set of individually administered tests designed to assess children's cognitive ability and academic achievement (Salvia & Ysseldyke, 1991; Woodcock & Johnson, 1989). The two subscales of the Woodcock-Johnson Battery, Dictation and Applied Problems, were used to assess Head Start children's literacy and mathematics skills. The Dictation subscale consists of 12 items, measuring children's prewriting skills (e.g., drawing lines) and skills in providing written responses when asked to write letters of alphabet, words, phrases, punctuations, and capitalization. The published validation study reported an average internal reliability of .90 with preschool age children (Woodcock & Johnson, 1989). Cronbach's alpha in the current study sample was slightly lower, but still adequate (.76–.80).

The Applied Problems subscale consists of 23 items, measuring children's skills in analyzing and solving practical problems in mathematics. In order to solve the problems, the child must recognize the procedure to be followed and then perform counting, addition, or subtraction operations. Published internal consistency reliability for the normative preschool-age sample was .91 (Woodcock & Johnson, 1989) and the current sample demonstrated a similar level of reliability (.89–.91). The one-parameter IRT scores (i.e., W scores) of the both Woodcock Johnson subscales were used in the present study.

In the field test of FACES, a floor effect was observed with the 3-year-old children for the Woodcock-Johnson subscales, indicating that the items were too difficult for the younger children in the sample (U.S. DHHS, 2005). Therefore, in the initial assessment in the fall of 1997, Woodcock-Johnson subscales were administered to 4-year-old children only. In addition, about one hundred 4-year-old children had one additional wave of assessment in Head Start in the spring of 1999 (when they should have been in kindergarten) because they repeated Head Start for one additional year. Please refer to Table 1 for descriptive statistics of child outcomes.

Table 1
Descriptive statistics of child outcomes by age cohort and assessment points.

	3-year olds			4-year olds			F-test
	N	Mean (SE)	Range	N	Mean (SE)	Range	
PPVT							
Fall 1997 Head Start	565	59.51 (.85)	6–88	749	69.39 (.93)	40–97	287.83***
Spring 1998 Head Start	591	65.34 (.77)	29–92	814	74.33 (.97)	40–101	223.63***
Spring 1999 Head Start	528	75.27 (.72)	35–102	96[a]	79.48 (1.47)	51–99	12.27***
Spring 1999 & 2000 Kindergarten	540	86.68 (.70)	54–115	762	84.91 (1.15)	46–108	.90
Spring 2000 & 2001 First Grade	444	93.36 (.65)	68–118	771	92.66 (1.03)	64–118	1.46
Woodcock-Johnson Applied Problem							
Fall 1997 Head Start	–	–	–	729	398.56 (1.27)	332–451	–
Spring 1998 Head Start	357	396.39 (2.26)	332–444	827	410.57 (1.43)	332–458	97.94***
Spring 1999 Head Start	538	417.65 (1.24)	332–461	100[a]	421.08 (3.00)	332–545	8.52**
Spring 1999 & 2000 Kindergarten	545	441.28 (.97)	332–481	774	437.80 (1.46)	356–481	3.31
Spring 2000 & 2001 First Grade	443	462.30 (.97)	421–492	779	461.41 (1.14)	332–492	.08
Woodcock-Johnson Dictation							
Fall 1997 Head Start	–	–	–	699	345.77 (2.10)	186–430	–
Spring 1998 Head Start	355	347.07 (2.51)	186–430	840	369.28 (1.80)	186–435	147.57***
Spring 1999 Head Start	535	373.71 (2.27)	186–435	98[a]	386.78 (2.61)	294–435	20.32***
Spring 1999 & 2000 Kindergarten	522	425.36 (1.89)	186–465	755	425.08 (1.91)	186–463	.28
Spring 2000 & 2001 First Grade	433	452.49 (.91)	406–474	776	448.87 (1.63)	186–474	1.59

Note. Unweighted *N*; other statistics were computed with the longitudinal child weight, longitudinal strata, and longitudinal cluster applied using SPSS Complex Samples v. 17.0.
3-year-old children were not assessed on the Woodcock-Johnson subscales in Fall97 due to an observed floor effect.
[a] About 100 4-year-old children were assessed in spring of 1999 Head Start because they were retained in Head Start for one additional year.
** $p < .01$.
*** $p < .001$.

5.2. Parent involvement

Head Start families' program, and home involvement were measured in FACES via primary caregiver interview in the spring of 1998, the spring of the first Head Start year. School-based involvement was assessed by a 7-item, 3-point scale (0 = not yet; 1 = once or twice; 2 = three or more times), adapted from the Head Start Quality Research Consortium (QRC). Parents were asked to report on how often they had been involved in their child's Head Start center or classroom activities, such as volunteering or helping out in child's classroom, observing in classroom, and attending Head Start social events. Internal consistency reliability for this scale was .75 for the study sample. The sample mean value for the scale was 3.86 (SD = 1.93), and values ranged from 0 to 7.

Parent home involvement was assessed by parents' report of their weekly and monthly activities using an adapted version of the National Household Education Survey (U.S. DHHS, 2005). Weekly home involvement was comprised of eight items quantifying the number of times parents were involved with their children's education in the home setting (e.g., told a story, taught letters, words, or numbers). Monthly home involvement was measured by seven items reflecting the number of times parents were involved with their children on special educational or cultural outings (e.g., took child to library, art gallery, or museum, or visited a zoo or aquarium). Reliability for this scale was low (α = .58 and .49, for weekly and monthly activities, respectively). However, this was the best available measure for this type of home involvement in the FACES. The average score of the scale in the current sample was 5.99, with a standard deviation of 2.51, ranging from 0 to 14.

5.3. Head Start classroom quality

Two widely used measures of classroom quality were adapted in the FACES: the Early Childhood Environment Rating Scale and the Arnett Caregiver Interaction Scale. Again, the spring 1998 data were used in the analysis.

The Early Childhood Environment Rating Scale (ECERS; Harms & Clifford, 1980) is a global rating of classroom quality based on structural features of the classroom. For the FACES 1997 study, 32 out of the 37 available items were used and the items were rate on a 7-point scale (1 = inadequate, 3 = minimal, 5 = good, and 7 = excellent). The scale measures seven areas of classroom quality: personal care routines, furnishings and display for children, language-reasoning experiences, fine and gross motor activities, creative activities, social development, and adult needs. The measure has been widely used in child care quality studies, with published inter-rater reliabilities above .80 and internal consistency of .83. For the current sample, the internal consistency reliability for the global mean score was .90 and inter-rater reliability was above .80. The average rating of the current sample was 5.03, with a standard deviation of .65, and ranged from 2.25 to 6.56, with higher scores representing better classroom quality.

The Arnett Caregiver Interaction Scale (Arnett, 1989) was used to measure teacher–child interactions and relationship quality. Trained observers rated Head Start teachers' behavior on 30 items comprising five dimensions: sensitivity, punitiveness, detachment, permissiveness, and prosocial interaction using a 4-point likert scale (0 = not at all, 1 = somewhat, 2 = quite a bit, and 3 = very much). Examples of observed teacher behaviors include speaking warmly to children, being attentive when children speak, and encouraging children to try new experiences. The lead teachers' total score was used for the present study (mean = 54.17, SD = 5.53, ranged from 4.5 to 61.2), with higher scores indicating that teachers were more sensitive and engaged with children and less punitive. The internal consistency reliability for the study sample was .93 and the inter-rater reliability was above .80.

5.4. Child and family characteristics

The child-level demographic covariates included in the longitudinal growth model were child gender, age in months at initial assessment (which was highly correlated with the ages at the follow up assessments, and therefore only this initial age was included in analysis), age cohort (a dummy code identifying whether the child was in 3- or 4-year-old cohort), ethnicity, language-minority status (i.e., speaking another language in addition to English at home), maternal education, family composition (i.e., mother–father household), maternal depression, and program location (urban vs. rural). The 12-item, 4-point Center for Epidemiologic Studies-Depression Scale (CES-D; Radloff, 1977) was administered to assess mothers' depressive symptoms. The scale had high reliability (.89 in current sample) and adequate variability (M = 7.36, SD = 6.55, and ranging from 0 to 35).

Bivariate correlations among the child and family characteristics, parent involvement, and classroom quality are summarized in Table 2. There were low to moderate associations among covariates (most correlations ranged from .002 to .33). There were only two moderate correlations: the two classroom quality measures were correlated at .57 and child's initial age in months and the dummy-coded age cohort variable were correlated at .84. Although the two age-related variables had a relatively high correlation, it was critical to include both in the model as each was hypothesized to contribute unique information to growth trajectories. Overall, collinearity among covariates in this model was very low (Tabachnick & Fidell, 2007).

6. Data analyses

6.1. Missing data

In the longitudinal sample, 64 children had no identified classroom ID, and therefore were excluded from the analyses. All predictors used in the model had minimal missing data (below 5%). Missing data for the categorical child-level demographic covariates were deleted using listwise deletion. Missing data for the continuous child-level covariates were estimated and replaced using mean-replacement in SPSS 18.0. The longitudinal child sampling weight was applied during the missing value computation. Although multiple imputation for replacement of missing values may introduce less bias in parameter estimates (Baraldi & Enders, 2009), Hierarchical Linear Modeling (Raudenbush & Bryk, 2002), the analytic approach and software applied for the current study, can accommodate multiply imputed data only at level 1, which represented the longitudinal outcome measures in this study. The missing data at level 2 (i.e., child-level covariates) could not be accommodated in HLM (v. 6.06), and therefore were replaced in SPSS using mean-replacement. Because HLM is designed such that all available data are used to estimate growth trajectories (using full maximum likelihood), missing data on repeated child outcome measures (level 1) is permitted as long as data are available for at least one time point. Table 1 shows that data were available at each assessment point, regardless of whether data were available for one or two age groups. Therefore, missing data on outcome variables were not addressed. Further, HLM provides flexibility in dealing with longitudinal data that have uneven waves of observations.

For the classroom-level quality measures, assuming relative stability in classroom measures from the fall of 1997 to the spring of 1998 (with spring measures being used in analysis), the spring missing data were replaced with fall scores. This resulted in a final sample size of 1640 for analysis.

Due to the complex sampling design of the FACES 1997, data were weighted with the longitudinal child base weight (CHLGWT0) to adjust for unequal selection probability. Classroom-level weights were not created in the FACES 1997 design and thus only child-level weights were applied. Because multilevel analysis is a model-based approach (Muthen & Satorra, 1995), variance estimation due to the stratification and clustering in the sampling design is addressed through the within and between partitioning of variation in the multilevel model.

6.2. Analytic approach

Multilevel piecewise growth models were used to investigate the growth trajectories of Head Start children's academic skills. Piecewise longitudinal models allow modeling of more than one slope (at a theoretically important break point) within children's growth trajectories (Singer & Willett, 2003). Initial inspection of the raw data suggested that the relationship between assessment time points and cognitive outcomes was not linear but rather as initially hypothesized—growth in Head Start appeared greater than in kindergarten and first grade. Therefore, two separate growth slopes were estimated: (a) a growth rate in Head Start, and (b) a growth rate in kindergarten and first grade.

For the PPVT outcome, the time variable for modeling growth rate was centered at the initial assessment, the fall of 1997. The time in Head Start was coded as (0, .5, 1.5, 1.5, 1.5), and the time in kindergarten-first grade was coded as (0, 0, 0, 1, 2). For the two Woodcock-Johnson subtests, since 3-year-old children were not assessed in the fall of 1997 due to a floor effect, the time variable for modeling growth rate was centered at the following spring where all children were assessed. The time in Head Start was coded as (−.5, 0, 1, 1, 1) and time in kindergarten-first grade was coded as (0, 0, 0, 1, 2). The time gap of .5 for the first and second wave of data collection aims to reflect the half-year gap between the fall of 1997 and the spring of 1998 data collection, while the other waves of observations had an one-year gap.

Piecewise multilevel growth models were used to estimate individual growth curves for children's academic outcomes from entry into Head Start through the end of first grade. Analyses were conducted in three steps. The first step was to examine unconditional growth models. Next, two-level contextual models were estimated which included time variables (level 1) and child and family covariates (level 2). Third, three-level contextual models were computed which allowed the examination of the unique and interactive effects of classroom quality.

In the models, level 1 represented repeated child outcome measures within children (i.e., intraindividual), level-2 predictors represented interindividual covariates (e.g., child and family demographic characteristics and parent involvement), and level-3 predictors represented the classroom quality measures. Level-2 predictors were grand-mean centered given the small n per classroom (approximately four children per classroom). All level-3 covariates were also grand-mean centered. The level-2 and level-3 intercepts were modeled as randomly varying. Also, because the interest was on the classroom level, the two growth slopes at level 3 were modeled as randomly varying.

The level 1 model was:

$$Y_{tij} = \pi_{0ij} + \pi_{1ij}(TIME\_HS)_{1tij} + \pi_{2ij}(TIME\_KG/FG)_{2tij} + e_{tij}$$

- Y_{tij} is the performance of child i in classroom j at time t.
- π_{0ij} is the initial status of child i in classroom j.
- π_{1ij} is the Head Start growth slope for the cognitive outcome for child i in Head Start classroom j and TIME_HS is Head Start exposure.
- π_{2ij} is the kindergarten and first grade growth slope for the cognitive outcome for child i in Head Start classroom j and TIME_KG/FG is kindergarten-first grade exposure.
- e_{tij} is temporal variation (i.e., time specific error for child i in classroom j at time t).

Intercept and two growth slopes in the level 2 model:

$$\pi_{sij} = \beta_{s0j} + \beta_{s1j}(AgeCohort)_{ij} + \beta_{s2j}(Age)_{ij} + \beta_{s3j}(Gender)_{ij} + \beta_{s4j}(RaceBlack)_{ij} + \beta_{s5j}(RaceHispanic)_{ij} + \beta_{s6j}(RaceOther)_{ij}$$

$$+ \beta_{s7j}(LanguageMinority)_{ij}$$
$$+ \beta_{s8j}(MaternalEdu)_{ij}\beta_{s9j}(MomDadHousehold)_{ij}$$
$$+ \beta_{s010j}(MaternalDepression)_{ij} + \beta_{s011j}(Location)_{ij}$$
$$+ \beta_{s012j}(HomeInvolve)_{ij} + \beta_{s013j}(HSInvolve)_{ij} + u_{sij}$$

- π_{sij} is the intercept or slopes from the level 1 model for child *i* in classroom *j*.
- β_{s0j} represents the mean intercept or mean growth rate in Head Start or kindergarten/first grade in classroom *j*.
- $\beta_{s1-013j}$ indexes the effect coefficients of thirteen level-2 (child-level) covariates. Please refer to the supplementary online materials for a full description of each covariate.

Intercept and two growth slopes in the level 3 model:

The level-3 intercept is presented as: $\beta_{00j} = \gamma_{000} + u_{00j}$.

The classroom quality variables were not modeled as predictors of the level-3 intercept because academic outcomes were initially measured in the fall of 1997, and the classroom quality variables used in this study were measured in the spring of 1998. The notation for Head Start growth slope is presented below (and the kindergarten/first grade growth slope, not shown here, follows similarly):

$$\beta_{10j} = \gamma_{100} + \gamma_{101}(ECERS)_j + \gamma_{102}(Arnett) + u_{10j}$$

- β_{10j} is the growth slope in Head Start for child *i* in classroom *j*.
- γ_{100} represents the mean growth rate in Head Start in classroom *j*.
- $\gamma_{101-102}$ indexes the effect of two level-3 variables: ECERS and Arnett classroom quality measures on the slope from level-2 model.
- u_{10j} is the level-3 random effects.

In addition, the two level-3 classroom quality measures were used to predict the effects of parent involvement variables on the Head Start slope and kindergarten-first grade slope from level-2 model. Please refer to the supplementary online materials for a more detailed description of the full model.

7. Results

7.1. Descriptive statistics of child outcomes

The descriptive statistics for the outcome measures across assessment points and disaggregated across the two age cohorts are presented in Table 1. The statistics were generated using SPSS Complex Samples (v. 18) with the longitudinal child weight (CHLGWT0), longitudinal strata (VARSTRAT) and cluster (VARUNIT) applied. The descriptive statistics showed that 4-year-old children demonstrated significantly higher mean academic outcome scores during the Head Start years (perhaps because that they were older); however, this group difference in performance was not observed during kindergarten and first grade.

7.2. Unconditional growth models

The null model (which did not include the time slopes, but only the intercepts) was estimated to partition the variability in child outcomes into within child (ranged from 23% to 48%), between child within classroom (ranged from 14% to 29%), and between-classroom variations (37–50%). The greatest variance lies between classrooms. The next step in model estimation was an unconditional growth model in which only the time variable (i.e., time in Head Start and time in kindergarten-first grade) was used to predict the outcomes. This level-1 model included four randomly varying parameters: the intercepts at level two (child level) and level three (classroom level) (β_{0ij}), linear growth during participation in Head Start at the classroom level (β_{1ij}), and linear growth during kindergarten and first grade at classroom level (β_{2ij}). Results from the unconditional growth models are summarized in Table 3. For each of the three outcomes, the mean score at baseline was statistically significantly different from zero, as were the slopes at both Head Start and kindergarten-first grade.

8. Contextual growth models

Conditional models included both child- and classroom-level covariates. Results are presented in Table 4. For the statistically significant coefficients, effect sizes were calculated as $(B_X \times SD_X)/SD_Y$, where SD_Y represents the variance term for the slope at the level at which *X* centers in the model. Effect sizes are, therefore, interpreted as ‘expected change in standard deviation units in *Y* (the intercepts or growth) that is associated with a standard deviation change in *X*.’ Effect sizes were not calculated for cross-level interactions as there is no convention for effect size estimation in these cases.

Table 2
Correlations among child and family characteristics, parent involvement, and classroom quality.

	Child age	Maternal depression	Home involvement	Head Start involvement	ECERS	Arnett
1. Age cohort (4-yar olds)	.84	−.06	.02	.01	.06	.04
2. Gender (girl)	−.05	−.01	.01	−.01	−.06	.02
3. Race–Black	−.06	.07	.08	−.07	−.21	−.19
4. Race–Hispanic	.05	−.15	−.06	−.01	−.003	.04
5. Race–Other	−.004	−.01	.05	−.02	−.01	.01
6. Language minority	.06	−.13	−.06	.03	−.01	.01
7. Maternal education (high school)	−.07	−.02	.09	.10	−.02	−.02
8. Mom–dad household	.002	−.20	−.004	.12	.06	.06
9. Program location (urban)	.08	−.07	.05	−.01	−.08	−.02
10. Child age	–	−.07	−.03	−.02	.08	.08
11. Maternal depression	–	–	−.05	−.02	.03	−.01
12. Home involvement			–	.33	−.03	−.04
13. Head Start involvement				–	.05	.05
14. ECERS					–	.57
15. Arnett						–

Note. Longitudinal child weight, longitudinal strata, and longitudinal cluster applied using AM software v. 6.03. The interactions among the dichotomous covariates were not computed, and significance levels could not be generated in AM software.

Table 3
Unconditional growth model for child outcome measures.

Fixed effects	PPVT Coefficient (SE)	WJ-Applied Problem Coefficient (SE)	WJ-Dictation Coefficient (SE)
Average intercept (γ_{000})	62.92 (.72)	402.76 (1.23)	355.30 (1.88)
Average Head Start slope (γ_{100})	9.74 (.34)	17.38 (1.05)	32.26 (1.90)
Average kindergarten-first grade slope (γ_{200})	7.56 (.24)	20.80 (.51)	32.81 (1.08)
Random Effects	Variance (df) [χ^2, p]	Variance (df) [χ^2, p]	Variance (df) [χ^2, p]
Level one variance			
Temporal variation (e_{tij})	28.95	139.53	473.72
Level two variance (within classrooms)			
Individual initial status (r_{0ij})	35.43 (673) [4113.68, <.001]	123.41 (665) [2491.52, <.001]	137.06 (663) [1401.73, <.001]
Level three variance (between classrooms)			
Classroom mean Head Start status (u_{00j})	64.11 (303) [1207.29, <.001]	156.19 (276) [888.08, <.001]	371.46 (280) [866.93, <.001]
Classroom mean Head Start growth rate (u_{10j})	6.36 (303) [446.70, <.001]	72.58 (276) [535.62, <.001]	210.55 (280) [483.73, <.001]
Classroom mean kindergarten-first grade growth rate (u_{20j})	3.37 (303) [376.72, .003]	5.72 (276) [366.87, <.001]	79.93 (280) [460.22, <.001]

Note. *P* values for all the fixed effects were <.001.

8.1. Initial status of receptive vocabulary in Head Start

The final conditional model indicated that, controlling for the other variables in the model, the initial PPVT (measured in the fall of 1997) average score was 63.37 (t = 124.07, p < .001; the interpretation of the IRT-based score was "below average", or equivalent to 81 points in the standard score metric).

Controlling for the other variables in the model, higher initial PPVT scores were predicted for children who were older (effect size = .02; t = 8.06, p < .001; with one month increases in ages, PPVT scores increased by .89 points), whose mother had a high school diploma or more education (effect size = .07; t = 4.27, p < .001; over four points higher), and whose parents were more involved with them at home (effect size = .06; t = 4.21, p < .001; one unit increases in home involvement was related to .62 points increase in PPVT); lower initial PPVT scores were predicted for African-American children (effect size = −.11; t = −4.65, p < 001; 6.04 points lower) and language-minority children (effect size = −.11; t = −3.52, p < .001; 6.54 points lower).

8.2. Growth in receptive vocabulary during Head Start through first grade

The Head Start slope measured child vocabulary growth rate during Head Start. On average, children gained about 9.18 points on the PPVT test per year during Head Start (t = 24.73, p < .001). Head Start growth was positively predicted by the Arnett measure of classroom quality (effect size = .19; t = 2.77, p = .01). As Table 4 indicates, child age negatively predicted children's growth rate during Head Start (effect size = −.06; t = −3.82, p < .001). In addition, parent home involvement was negatively associated with child vocabulary growth during Head Start (effect size = −.02; t = −2.31, p = .02). This negative effect of home involvement was negatively moderated by the Arnett (t = −2.05, p < .04), which suggested that the negative effect of home involvement was exacerbated for children in classrooms with higher quality. When the Arnett score increased, the negative effect of home involvement also increased.

To illustrate this moderation effect, children's vocabulary growth trajectories were plotted by high and low classroom quality (low vs. high quality scores were selected at the 20% and 80% of the Arnett score distribution), and across three levels of parent home involvement (low involvement, one SD below the mean; medium involvement, equal to the mean; and high involvement, one SD above the mean). The plots were made based on the model estimation for PPVT, controlling for the irrelevant covariates (e.g., age and gender) as a constant (i.e., 0). As shown in Fig. 1(a) and (b), initial parent home involvement was positively associated with initial performance and this was true in both high-and low-quality classrooms. But the negative association between home involvement and vocabulary growth during Head Start (data collection point 1–2) was stronger in high-quality classrooms.

The kindergarten/first grade slope measured child vocabulary growth rate during kindergarten and first grade. On average, children gained about 8 points per year during kindergarten and first grade, which was a slightly slower growth rate than during the Head Start years (t = 32.40, p < .001). Kindergarten-first grade growth was negatively predicted by the Arnett classroom quality measure (effect size = −.35; t = −2.02, p = .04; for every one point increase in Arnett quality, change in PPVT score decreased by .04 points, which is a relatively minor effect). Controlling for the other variables, the kindergarten/first grade growth rate was lower for 4-year-old cohort of children who experienced only one year of Head Start (effect size = −.03; t = −2.43, p = .02; about 1.66 points less in growth). Growth in kindergarten-first grade was also negatively affected by child age at initial assessment (decreasing by about .12 points for every one month increase in age; effect size = −.03; t = −2.15, p = .03) and mother's education (decreasing by nearly one point for children whose mother had a high school diploma or more education; effect size = −.02; t = −2.13, p = .03). Controlling for other variables, language-minority status positively predicted children's vocabulary growth in kindergarten and first grade (effect size = .04; t = 2.28, p = .02). Although the main effect of parent home involvement was not statistically significant, classroom quality as measured by the Arnett positively moderated the effect of parent home involvement on vocabulary growth in kindergarten-first grade (t = 2.06, p = .04). As the Arnett score increased, the positive effect of home involvement was enhanced. As demonstrated in Fig. 1(a) and (b), the positive association between parent home involvement and vocabulary growth during kindergarten and first grade (data collection point 2–3) was stronger in high-quality classrooms.

The non-overlapping 95% of confidence intervals for the Head Start and kindergarten/first grade growth rates (8.45–9.90 vs. 7.13–8.05) suggested a statistically significant difference in the average receptive vocabulary growth rates between the two time periods, with greater growth during Head Start than in kindergarten/first grade.

Table 4
Final contextual growth model for child outcome measures.

Fixed effects	PPVT Coefficient (SE)	WJ-Applied Problem Coefficient (SE)	WJ-Dictation Coefficient (SE)
Model for initial status (π_{0ij})			
Intercept (γ_{000})	63.37 (.51)***	400.95 (1.16)***	354.65 (1.86)***
Age Cohort (4-year olds) (γ_{010})	.67 (1.52)	−4.02 (3.13)	2.71 (4.47)
Child age (γ_{020})	.89 (.11)***	1.36 (.25)***	1.94 (.37)***
Child gender (girls) (γ_{030})	−.04 (.77)	2.75 (1.70)	8.55 (2.43)***
Race–Black (γ_{040})[a]	−6.04 (1.30)***	−8.37 (2.54)***	−6.13 (4.46)
Race–Hispanic (γ_{050})[a]	−3.24 (1.77)	−1.94 (3.63)	−.13 (5.16)
Race–Other (non-white) (γ_{060})[a]	.27 (2.03)	−.56 (3.67)	.04 (6.56)
Language minority (γ_{070})[b]	−6.54 (1.86)***	−10.36 (3.18)***	.56 (5.11)
Maternal education (high school or greater) (γ_{080})[c]	4.30 (1.01)***	1.09 (2.08)	1.91 (2.84)
Mother–father household (γ_{090})[d]	−.16 (.94)	−.51 (2.13)	−2.02 (3.02)
Maternal depression (γ_{0100})	.10 (.05)	.19 (.13)	.01 (.21)
Program location (urban) (γ_{0110})[e]	−.83 (1.12)	.21 (2.32)	4.44 (3.99)
Parent involvement at home (γ_{0120})	.62 (.15)***	.41 (.34)	−.32 (.52)
Parent involvement in Head Start (γ_{0130})	.09 (.27)	.83 (.55)	.77 (.73)
Model for Head Start growth rate (π_{1ij})			
Intercept (γ_{100})	9.18 (.37)***	19.41 (1.03)***	39.66 (2.17)***
Intercept*ECERS (γ_{101})	−.38 (.47)	−.48 (1.58)	−.75 (2.90)
Intercept*Arnett (γ_{102})	.09 (.03)**	.14 (.07)*	.28 (.18)
Age Cohort (4-year old cohort) (γ_{110})	−1.39 (.94)	−3.02 (2.80)	7.30 (5.62)
Child age (γ_{120})	−.28 (.07)***	−.44 (.24)	−.59 (.45)
Child gender (girls) (γ_{130})	−.26 (.62)	−2.14 (1.73)	−3.95 (3.03)
Race–Black (γ_{140})[a]	−.23 (.87)	−.28 (2.26)	8.36 (4.63)
Race–Hispanic (γ_{150})[a]	.71 (1.42)	−1.63 (3.72)	6.63 (6.12)
Race–Other (non-white) (γ_{160})[a]	1.57 (1.35)	4.18 (3.87)	−4.07 (6.18)
Language minority (γ_{170})[b]	−1.21 (1.57)	6.64 (3.41)	.14 (6.27)
Maternal education (high school or greater) (γ_{180})[c]	−.45 (.78)	.58 (1.87)	3.66 (3.56)
Mother–father household (γ_{190})[d]	.14 (.63)	1.37 (2.11)	.27 (3.59)
Maternal depression (γ_{1100})	.01 (.04)	.02 (.11)	−.22 (.23)
Program location (urban) (γ_{1110})[e]	.26 (.64)	2.58 (1.89)	−1.36 (3.89)
Parent involvement at home (γ_{1120})	−.26 (.11)*	−.34 (.31)	−.27 (.60)
Parent involvement at home*ECERS (γ_{1121})	.01 (.19)	−.60 (.42)	−.74 (1.02)
Parent involvement at home*Arnett (γ_{1122})	−.02 (.01)*	.002 (.03)	−.04 (.05)
Parent involvement in Head Start (γ_{1130})	.28 (.20)	−.40 (.48)	−.19 (.93)
Parent involvement in Head Start*ECERS (γ_{1131})	.22 (.32)	.93 (.67)	−.46 (1.31)
Parent involvement in Head Start*Arnett (γ_{1132})	.01 (.01)	.003 (.04)	.07 (.06)
Model for kindergarten-first grade growth rate (π_{2ij})			
Intercept (γ_{200})	7.59 (.23)***	20.42 (.56)***	28.89 (1.08)***
Intercept*ECERS (γ_{201})	−.07 (.39)	.67 (.81)	.64 (1.57)
Intercept*Arnett (γ_{202})	−.04, (.02)*	−.08 (.04)	−.10 (.10)
Age cohort (4-year old cohort) (γ_{210})	−1.66 (.68)*	.41 (1.93)	−9.12 (4.15)*
Child age (γ_{220})	−.12 (.05)*	−.30 (.15)*	−.69 (.30)*
Child gender (girls) (γ_{230})	.15 (.38)	−1.34 (.93)	−1.77 (1.74)
Race–Black (γ_{240})[a]	.54 (.56)	1.62 (1.16)	−2.96 (2.55)
Race–Hispanic (γ_{250})[a]	.17 (.89)	2.11 (2.02)	−5.81 (3.09)
Race–Other (non-white) (γ_{260})[a]	−.49 (.76)	−2.69 (2.08)	3.43 (4.82)
Language minority (γ_{270})[b]	2.24 (.98)*	.02 (1.67)	−1.26 (3.45)
Maternal education (high school or greater) (γ_{280})[c]	−.96 (.45)*	−.35 (1.15)	−2.03 (2.18)
Mother–father household (γ_{290})[d]	−.22 (.42)	.04 (.96)	2.53 (2.07)
Maternal depression (γ_{2100})	−.02 (.03)	−.05 (.07)	.23 (.14)
Program location (urban) (γ_{2110})[e]	.39 (.46)	−1.26 (1.22)	−.33 (2.13)
Parent involvement at home (γ_{2120})	.019 (.072)	−.07 (.15)	.17 (.36)
Parent involvement at home*ECERS (γ_{2121})	.08 (.13)	.61 (.25)*	.85 (.68)
Parent involvement at home*Arnett (γ_{2122})	.01 (.01)*	−.01 (.01)	.01 (.04)
Parent involvement in Head Start (γ_{2130})	−.15 (.11)	−.002 (.24)	.06 (.52)
Parent involvement in Head Start*ECERS (γ_{2131})	−.30 (.21)	−.59 (.40)	−.07 (.68)
Parent involvement in Head Start*Arnett (γ_{2132})	−.01 (.01)	.02 (.01)	−.02 (.05)
Random Effects (Variance Components)	Variance (df) [χ^2, p]	Variance (df) [χ^2, p]	Variance (df) [χ^2, p]
Level one variance			
Temporal variation (e_{tij})	25.17	134.02	432.36
Level two variance (within classrooms)			
Individual initial status (r_{0ij})	27.76 (66) [3864.64, <.001]	116.24 (654) [2574.45, <.001]	130.04 (652) [1420.39, <.001]
Level three variance (between classrooms)			
Classroom mean Head Start status (u_{00j})	21.82 (303) [722.92, <.001]	89.10 (276) [651.39, <.001]	300.96 (281) [743.38, <.001]

Table 4 (*Continued*)

Random Effects (Variance Components)	Variance (df) [χ^2, p]	Variance (df) [χ^2, p]	Variance (df) [χ^2, p]
Classroom mean Head Start growth rate (u_{10j})	5.437 (301) [508.87, <.001]	41.96 (274) [460.58, <.001]	246.24 (279) [513.73, <.001]
Classroom mean kindergarten-first grade growth rate (u_{20j})	1.349 (301) [328.10, .14]	2.79 (274) [356.83, <.001]	51.53 (279) [372.76, <.001]

* $p < .05$.
** $p < .01$.
*** $p < .001$.
[a] Reference category is White.
[b] Reference category is non language minority.
[c] Reference category is no high school diploma or GED.
[d] Reference category is non mother–father household.
[e] Reference category is rural.

8.3. Initial status of mathematics skills in Head Start

Since 3-year-old children were not administered the Woodcock-Johnson test at the initial assessment in the fall of 1997 due to a floor effect, the time variable for modeling mathematics skill growth was centered at the following spring, the end of the first year of Head Start, when all children were tested. Thus the intercept presented in Table 4 indicates that, on average, at the end of the first year of Head Start, children scored about 401 points on the Woodcock-Johnson Applied Problems test ($t = 346.26$, $p < .001$; this IRT-based score was “below average,” or equivalent to 83 points in the standard score metric). Older children achieved higher initial mathematics scores (effect size = .07; $t = 346.26$, $p < .001$). Children who were African American (effect size = −.04; $t = -3.30$, $p = .001$) and language minority (effect size = −.04; $t = -3.26$, $p = .002$) had lower initial mathematics scores.

8.4. Growth in mathematics skills during Head Start through first grade

During Head Start, on average, children gained 19.41 points in mathematics achievement each year ($t = 18.91$, $p < .001$), and this growth was positively predicted by the Arnett classroom quality measure (effect size = .04; $t = 1.99$, $p = .05$). No other covariates were statistically significant ($p < .05$) in predicting mathematics growth during Head Start.

During kindergarten and first grade, on average, children gained 20.42 points in mathematics achievement per year ($t = 36.43$,

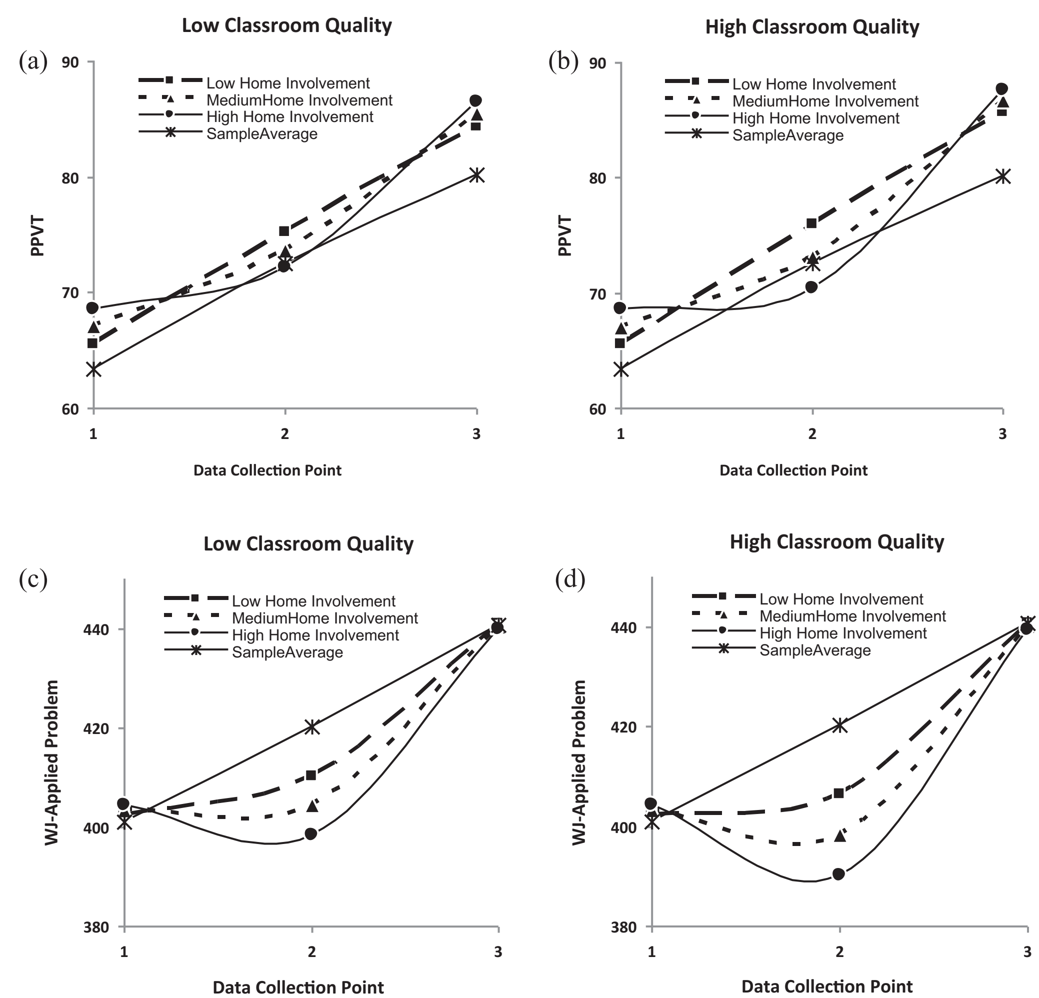

Fig. 1. Classroom quality moderated the association between parent home involvement and children’s vocabulary and mathematics growth.

$p < .001$), which was a slightly higher growth rate than during Head Start. The growth during kindergarten and first grade was negatively associated with children's age (effect size = −.02; $t = -2.21$, $p = .004$). Parent home involvement was positively moderated by the ECERS classroom quality measure (although the main effect of parent involvement was not significant) ($t = 2.45$, $p = .02$). As ECERS scores increased, the negative effect of parent home involvement on children's mathematics growth rate during kindergarten and first grade period was reduced. This interaction effect is illustrated in Fig. 1(c) and (d). However, the difference in the strength of the association between parent home involvement and mathematics growth during kindergarten/first grade among high- and low-quality classrooms was relatively small. The overlapping of the 95% confidence intervals for the Head Start and kindergarten/first grade growth rates (17.40–21.43 vs. 19.32–21.51) suggested there was no statistically significant difference in the average mathematics skills growth rate between the two time periods.

8.5. Initial status of literacy skills in Head Start

As mentioned before, since 3-year-old children did not have the Woodcock-Johnson test at the initial assessment, the time variable for modeling child literacy skill growth was centered at the end of the first year of Head Start when all children were tested. The final conditional model suggested that, on average, at the end of the first year of Head Start, children received an average score of 354.65 on the Woodcock-Johnson Dictation test ($t = 190.42$, $p < .001$; this IRT-based score was "below average," or equivalent to 84 points in the standard score metric). Girls and older children received higher scores. On average, girls scored 8.55 points higher than boys (effect size = .03; $t = 3.51$, $p < .001$) and with every one month increase in age, children's literacy scores increased by 1.94 points (effect size = .09; $t = 5.23$, $p < .001$).

8.6. Growth in literacy skills during Head Start through first grade

During Head Start, on average, children gained approximately 40 points in literacy skills each year. No child and family variables or classroom quality variables statistically significantly predicted the growth rate in Head Start.

During the kindergarten and first grade years, on average, children gained about 29 points in literacy skills, which was significantly lower than the growth rate in Head Start years ($t = 26.76$, $p < .001$). Again, this growth rate was slower (about 9 points) for 4-year-old children who attended only one year of Head Start as compared to 3-year-old children who received two years of Head Start (effect size = −.03; $t = -2.20$, $p = .03$). Similar to the other two child outcomes, growth in literacy skills decreased by .69 points as children's age increased by one month (effect size = −.03; $t = -2.27$, $p = .02$). The non-overlapping 95% confidence intervals for the Head Start and kindergarten/first grade growth rates (35.40–43.92 vs. 26.78–31.09) suggested that there was a statistically significant difference in literacy skills growth between the two time periods.

9. Discussion

The current study represents an effort to understand low-income children's academic achievement trajectories from Head Start through kindergarten and first grade by examining the unique and interactive effects of parent involvement and classroom quality on language, literacy, and mathematics growth. Overall, findings suggested positive growth over time for all children, with inter-individual differences in initial status and rates of change. Child and family characteristics, parent home involvement, and classroom quality all contributed to children's academic growth, but in rather complex ways.

Models suggested that children's performance at initial assessment was positively associated with their age and maternal education (PPVT only), and negatively associated with ethnic-minority and language-minority status (PPVT and WJ Applied Problems). However, low maternal education and language-minority status predicted faster growth in vocabulary skills (PPVT) during kindergarten and first grade. These findings replicate a number of studies showing that although children and families from disadvantaged backgrounds are more likely to demonstrate academic difficulties upon preschool and elementary school entry (e.g., Barbarin et al., 2006; Brooks-Gunn, 2003; Wolfe & Scrivner, 2003), they tend to benefit more from high-quality education programs (e.g., Bradley, Burchinal, et al., 2001; Bradley, Corwyn, et al., 2001; Burchinal et al., 2002; Olds et al., 2002; U.S. DHHS, 2010).

With respect to academic growth over time, it is very promising to see that Head Start children displayed overall positive growth trajectories in all three academic areas during Head Start and across the transition into first grade. In addition, the piece-wise growth model makes a contribution to the literature by showing that in Head Start, growth rates for vocabulary and literacy skills were higher than in kindergarten and first grade. Given that children were only followed into first grade, it is impossible to examine whether the initial positive growth trajectories we identified will be maintained for Head Start children for a longer period of time. More extensive longitudinal studies are needed to examine this question.

Surprisingly, we found few main effects for our two key variables of interest (parent involvement and Head Start classroom quality) on academic growth, once child, family, and programmatic characteristics were accounted for in the growth models. Two main effects were found for parent involvement. First, a positive association was found between parent home involvement and children's initial vocabulary scores. This finding is supported by a broader literature acknowledging the important direct influence of home involvement on children's early language development (Harris & Goodall, 2008). We also found a small but significant negative association between home involvement and growth in vocabulary skills during children's Head Start years. One possible explanation for this negative association is that children with initially lower receptive vocabulary skills experienced less enrichment within the home environment (as compared to children whose parents were more involved in home learning) and had more opportunities to "grow" across the year. This finding is in accord with developmental risk and resilience research, documenting additional benefits of high-quality classroom environments for groups of at-risk children (e.g., Hamre & Pianta, 2005).

Counter to our initial hypotheses, no significant associations were found between parent school-based involvement in Head Start and children's growth in academic skills. This may be related to the fact that school involvement was measured with fewer items compared to home involvement (7 vs. 15), and the items (all parent self-report) demonstrated relatively low internal consistency within the FACES sample. As a consequence, the measure might not have captured enough variation within the sample, and thus limiting its ability to meaningfully predict growth.

As for classroom quality, only the Arnett measure of teacher–child relationships during Head Start was significantly positively associated with children's vocabulary and mathematics growth in Head Start. Unexpectedly, we found that this quality measure of the teacher–child relationships was negatively associated with vocabulary growth during kindergarten and first grade, although the effect size was small. One potential interpretation is that children who experienced higher-quality teacher–child relationships during preschool might be more vulnerable while they transition into kindergarten and first grade.

The limited finding with classroom quality measures could again be a measurement issue. Head Start classroom quality showed limited variability (with the majority of classrooms displayed "good" global quality on the ECERS and Arnett measures), which might have made it difficult for our models to detect main effects with these variables. Other studies that focus specifically on Head Start or state-funded pre-kindergarten programs also have found limited effects of classroom quality on children's academic outcomes (e.g., Hindman et al., 2010; Magnuson et al., 2007), and this might be related to the fact that quality is more closely monitored or regulated in these programs. In addition, classroom quality was measured at the classroom level and this global measure may not capture the interaction quality between a specific pair of child and caregiver, and therefore may have limited predictive ability for individual children.

While we found few main effects for classroom quality on children's academic growth trajectories, we did find significant moderating effects of classroom quality variables on the relationship between parent home involvement and growth in receptive vocabulary and mathematics skills. First, the quality of teacher–child interactions positively moderated associations between home involvement and children's vocabulary growth during kindergarten and first grade. Although the positive main effects of parental home involvement on vocabulary skills growth in kindergarten and first grade was not statistically significant, for children who experienced higher-quality teacher–child interactions in Head Start, this association was strengthened. This finding supports the research hypothesis that positive developmental outcomes are more likely when both early childhood classrooms and family environment are complementary and both encourage early learning (Burchinal et al., 2002; Downer & Pianta, 2006).

A second interaction was found between the ECERS, measuring largely the structural quality features of the classroom, and parent home involvement in the prediction of children's mathematics growth in kindergarten and first grade. For children who experienced higher-quality preschool classrooms, the negative association between home involvement and mathematics skills growth during kindergarten and first grade was weakened. One possible explanation could be that children whose parents were highly involved at the beginning of Head Start also had higher initial mathematics skills, and therefore had less "room to grow" relative to their more disadvantaged peers. High-quality classroom experiences in Head Start, therefore, buffered the negative influence of home involvement on mathematics skill growth in kindergarten and first grade: the rate of academic growth did not slow down as much for children who initially had higher levels of parent home involvement. This finding is supported by the literature that suggests quality preschool experiences serve as a protective factor for low-income children whose family environments may not contribute much to their academic growth (McCartney et al., 2007).

A significant negative interaction was also found between parent home involvement and the quality of teacher–child interactions in the prediction of vocabulary skills growth during Head Start. This finding suggested that a higher-quality preschool classroom experience enhanced the negative association between parental home involvement and vocabulary growth during Head Start. Given that this is a correlational study, one possible interpretation of this finding is that there is some selection bias for Head Start parents in the sample: more highly involved parents in the home may select into higher-quality classrooms (e.g., Castro et al., 2004). As discussed earlier, it is possible that children who initially began Head Start with higher vocabulary skills (having experienced higher-level of parent involvement in home), may be growing at a slower rate. This might explain, in part, the stronger negative association that we found between parents' initial home involvement and children's later vocabulary growth in higher-quality classrooms where parent involvement level might be higher due to potential selection bias.

It is challenging to interpret some of the interaction effects we found between parent involvement and Head Start classroom quality, especially when our outcome variable was children's academic growth rate. In most parent involvement research, the outcome variable is usually a concurrent measure of child performance assessed at a certain time point. It is a complex task to understand these interaction effects on academic growth, because the rate of growth could be in part due to children's initial skills at Head Start entry and how much room they have to change across the year. Further, children's academic growth rates in kindergarten and first grade could be affected by many factors that were not measured in FACES 1997, such as time-varying measures of the classroom quality during elementary school. Our study highlights the difficulty of disentangling the complex interactions in a longitudinal growth model among several important factors across proximal settings as they shape children's development over time.

Our study's findings regarding the nature of Head Start children's academic growth make an important contribution to existing literature. Given the design features of the FACES 1997 study, the current sample included two different age cohorts, which created analytic challenges but also granted an opportunity to examine group differences in growth trajectories. We found that both child age (as a continuous predictor) and the dummy-coded age cohort variable were significantly negatively associated with children's rate of growth, especially during kindergarten and first grade. Older children (compared to the overall sample) and children in the 4-year-old cohort grew slower in vocabulary, literacy, and mathematics skills compared to younger children. The descriptive statistics in Table 1 also showed that during Head Start, 4-year-old children scored consistently higher on all three outcomes, but that this trend disappeared as soon as children transitioned into kindergarten.

The difference in academic growth rate between the two age cohorts might be due to differences in children's initial performance at the outset of children's entry into Head Start. As discussed earlier, since 4-year-old children started with higher initial performance, their rate of change in academic skills was slower than 3-year-old children. Another possible explanation might be related to individual differences in the timing of when children started Head Start and duration of their participation in the program. Compared to 4-year-old children, 3-year-old children started the program at a younger age and were eligible to stay in Head Start for a longer period of time; and therefore perhaps they had more opportunity to benefit from the program. Previous studies provide some evidence to support the positive effects of early timing and length of exposure to quality educational experiences (e.g., Campbell & Ramey, 1995). Comparisons between 3- and 4-year-old children in their academic growth are critical because both Head Start and state-funded prekindergarten programs mainly serve these two age groups of children and there is some public policy tension in determining funding priorities for each age group (Barnett, Hustedt, Robin, & Schulman, 2004). Robust experimental design holds promise to extend our understanding of the long-term effects of early interventions that target younger children and continue for a longer period of time.

In conclusion, the current study suggests positive growth in Head Start children's vocabulary, literacy, and mathematics skills from their entry in Head Start through first grade follow up, with more rapid growth in Head Start and more rapid growth for younger children. Parent involvement and Head Start classroom quality showed interactive effects on children's academic growth, although the effects were relatively small. The study demonstrates the complexity of the interactions between family and school factors as they affect children's growth. Further research with more robust designs and measures are needed. Given a recent national push to expand Head Start and state-funded pre-kindergarten programs to enhance school-related academic skills and social–behavioral competence before children enter kindergarten (Howes et al., 2008), careful empirical examinations of the interrelationships among child and family characteristics, program characteristics, and children's program participation are critical to promote program quality and maximize children's early academic success.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ecresq.2012.01.004.

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