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Effects of the Getting Ready for School intervention on children's school readiness skills

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Introduction: Skill-based curricula supplementing Head Start programming have shown great promise as early interventions improving school readiness of children from socioeconomically under-resourced families. The Getting Ready for School (GRS) intervention builds on such research by providing a supplemental skill-based curriculum targeting three core school readiness domains—language/literacy, math, and self-regulation—using learning activities aligned across the classroom and home contexts. The goal of this study was to examine the effects of the GRS intervention on school readiness skills in children in Head Start programs.

Methods: Participants were 3- to 4-year-olds (N = 463, 46% male, 81% Hispanic/Latine). Classrooms were non-randomly assigned to the GRS intervention (n = 20) or Head-Start-as-usual comparison group (n = 17). At pretest and posttest, children completed assessments of early language/literacy, math, and self-regulation. Multilevel modeling was used to examine the group-by-time interaction in prediction of children's school readiness skills.

Results: Significant group-by-time interactions were found for early language/literacy (vocabulary, print knowledge) and math skills. Children in the intervention group demonstrated significantly greater gains over time in these skills compared to children in the comparison group. At posttest, children in the intervention group had significantly higher vocabulary than children in the comparison group (effect size = 0.34). Intervention effects were not found for self-regulation.

Discussion: The GRS intervention may support early language/literacy and math skills in preschool children from socioeconomically under-resourced families. Future studies focused on a modified version of the intervention could demonstrate larger effect sizes and improvements in self-regulation.

KEYWORDS

Head Start, early intervention, school readiness, Hispanic/Latine children, early childhood education, literacy, executive function, home environment

Introduction

School readiness skills, including pre-academic (e.g., language/literacy, math), self-regulatory, and socioemotional skills, provide the foundation for academic achievement (Romano et al., 2010; Lonigan et al., 2017; Manfra et al., 2017; Sabol and Pianta, 2017; Suggate et al., 2018; Dickinson et al., 2019). Children entering school with high levels of these skills tend to attain higher grades, remain in school longer, and are more likely to graduate from high school (Hair et al., 2006; Duncan et al., 2007; Sabol and Pianta, 2012; Quirk et al., 2013). Children from socioeconomically under-resourced families often start school with significantly lower school readiness compared to their peers from more resourced families (Bradley and Corwyn, 2002; Barbarin et al., 2006; Merz et al., 2014; Sabol and Pianta, 2017). Publicly-funded early childhood education (ECE) programs such as Head Start are only moderately effective at increasing school readiness in children from socioeconomically under-resourced families (Duncan et al., 2023; Burchinal et al., 2024). In this study, we examined the effects of a supplemental, targeted intervention—Getting Ready for School (GRS)—on school readiness in children in Head Start programs.

Socioeconomic disparities in school readiness

Socioeconomic disadvantage is associated with lower early language/literacy (e.g., vocabulary, phonological processing, print knowledge), early math (e.g., numeracy), and self-regulation in young children prior to school entry (Clements and Sarama, 2011; Merz et al., 2014; Sabol and Pianta, 2017; Vrantsidis et al., 2020). In the self-regulation domain, socioeconomic disadvantage has been repeatedly associated with lower executive function in children (Lawson et al., 2018). These socioeconomic disparities in school readiness have been found to emerge early in life (Fernald et al., 2013; Noble et al., 2015) and are attributable to socioeconomic differences in children's early experiences (Bradley and Corwyn, 2002; Conger and Donnellan, 2007). For example, socioeconomic disadvantage often leads to reduced cognitive stimulation and increased chronic stress (e.g., household instability, noise/crowding, family conflict), which interfere with the development of school readiness skills in children (Gershoff et al., 2007; Pace et al., 2017). Socioeconomic disparities in school readiness likely partially explain the well-documented socioeconomic status (SES) opportunity gap that persists, or even widens, over time (Reardon, 2011). Children of minoritized racial and ethnic backgrounds (e.g., Black/African American, Hispanic/Latine) are disproportionately exposed to socioeconomic disadvantage in the United States (U.S.), often experience racial/ethnic discrimination, and have been found to exhibit lower school readiness (Palermo et al., 2018; Bustamante and Hindman, 2020).

Head Start

Head Start is a comprehensive federally-funded ECE program in the U.S. that aims to increase school readiness skills in 3- and 4-year-old children from socioeconomically under-resourced families. Children from low-income families are eligible for Head Start. Head Start serves a range of racial/ethnic backgrounds, with most children reported to be Black/African American or Hispanic/Latine. Research spanning across decades has indicated that Head Start is only moderately effective at improving children's school readiness skills (Duncan and Magnuson, 2013; Jenkins et al., 2018; Duncan et al., 2023). Although significant impacts in the short-term have been documented, there is evidence that these effects are not maintained over time (Puma et al., 2012; Burchinal et al., 2024). Other studies have suggested that effects vary depending on multiple factors, including sample characteristics, initial skill level, and comparison group (Puma et al., 2010; McCoy et al., 2016).

Classroom-focused interventions

Researchers have collaborated with Head Start programs to implement and test the effects of interventions designed to bolster school readiness in children. One promising approach consists of content-specific curricula (or curricular supplements) combined with professional development and coaching for teachers (Markowitz et al., 2018; Weiland et al., 2018). Content-focused (i.e., content-specific, skill-based) curricula target explicit skill growth by focusing on content areas following a developmental sequence and providing teachers with learning activities targeting specific skills (Jenkins et al., 2018; Joo et al., 2020). Coupled with intensive professional development, content-focused curricula have been found to improve school readiness among children in Head Start (Lonigan et al., 2011; Bierman et al., 2014; Morris et al., 2014; Schmitt et al., 2015; Jenkins et al., 2018; Nguyen et al., 2018; Weiland et al., 2018; Joo et al., 2020). Content-specific curricula have been found to improve children's outcomes in the targeted domain. For example, curricula targeting early math skills demonstrate efficacy in improving preschoolers' math concepts and skills (Clements and Sarama, 2007, 2008, 2011; Wakabayashi et al., 2020; Starkey et al., 2022).

Content-focused interventions targeting specific school readiness skills are inconsistent in improving other school readiness skills not targeted by the intervention (Sarama et al., 2012; Weiland and Yoshikawa, 2013; Morris et al., 2014; Schmitt et al., 2015; Upshur et al., 2019). Therefore, interventions have been designed that target more than one school readiness domain (Diamond et al., 2007; Barnett et al., 2008; Bierman et al., 2014; Farran and Wilson, 2014; Clements et al., 2020). For example, the combination of literacy- and math-focused curricula has been found to improve emergent literacy and math in children in a mixed set of preschool programs including Head Start programs (Lonigan et al., 2015). In addition, the Head Start REDI (Research-Based Developmentally Informed) program, which provides a supplemental curriculum targeting early language/literacy, socioemotional skills, and self-regulation along with professional development to teachers, demonstrates significant effects on language/literacy and self-regulation (Bierman et al., 2014; Welsh et al., 2020).

However, few studies have examined skill-based curricula focused simultaneously on early language/literacy, math, and

self-regulation. In one study, positive effects were found in all three school readiness domains (Lonigan et al., 2015). In another prior study, an intervention in which teachers implemented circle time self-regulation games with embedded math and literacy content was found to have positive effects on early math and self-regulation but not early literacy (McClelland et al., 2019). In the current study, we add to this literature by examining the effects of an early intervention targeting early language/literacy, math, and self-regulation by enhancing the classroom and home environments on children's school readiness.

Interventions focused on the home context

Another intervention approach is to focus on the family context to improve school readiness in children in Head Start. Parents' warm, responsive, and stimulating interactions with children have been found to support early socioemotional and cognitive development (Merz et al., 2015). In addition, parental involvement in children's early learning and education supports development in multiple domains (Barger et al., 2019; Jeon et al., 2020; Cosso et al., 2022). In socioeconomically under-resourced families, on average, less time is spent on children's learning activities (e.g., book reading), fewer learning materials and experiences are provided, and there are fewer or lower-quality adult-child conversational exchanges compared to more resourced families (Bradley and Corwyn, 2002; Conger and Donnellan, 2007; Gershoff et al., 2007; Guryan et al., 2008; Pace et al., 2017).

A range of parent- and home-based interventions have been designed as "add-ons" to Head Start programming. Many have been found to improve parenting knowledge, quality of parent-child interactions, parent engagement in children's learning, and children's school readiness skills (Welsh et al., 2014; Joo et al., 2020; Bierman et al., 2023). For example, interventions that work with parents to support their use of learning activities at home and emphasize family-school partnership lead to increased school readiness in children (Sheridan et al., 2010, 2011; Welsh et al., 2014; Bierman et al., 2015; Magnuson and Schindler, 2016; Joo et al., 2020).

Classroom-based interventions supplementing Head Start programs have often overlooked the important role that parents play. This decision ignores the importance of continuity in learning experiences between school and home and the key role of parental engagement in children's education (Welsh et al., 2014; Jones et al., 2017). Although home- and preschool-based interventions significantly increase support for school readiness in the home and classroom, respectively, children may not experience support across these contexts. Only a few studies have examined the effects of early interventions that target both the classroom and home environments on children's school readiness skills (Anthony et al., 2014; Landry et al., 2017, 2021; Young et al., 2023). For example, the Head Start REDI parent (REDI-P) program with aligned home and classroom components has been found to improve language/literacy and socioemotional skills in children (Bierman et al., 2015). Taken together, there is a gap in research examining the benefits of supplemental, skill-based curricula targeting early language/literacy, math, and self-regulation through integrated classroom and home components. The present study aimed to fill this gap.

Getting Ready for School (GRS) intervention

The GRS intervention provided a supplemental curriculum targeting the development of language/literacy, early math, and self-regulation by enhancing the classroom and home environments (Noble et al., 2012). The intervention was designed to increase teachers' and parents' use of simple, sequenced learning activities intended to foster the development of school readiness skills in children (Marti et al., 2018a). Given the co-development of pre-academic and self-regulatory skills during early childhood, GRS learning activities were designed to simultaneously support the development of these skills through a single, content-focused curriculum aligned across the classroom and home contexts (Marti et al., 2018b) (see Supplementary material). Prior work involving a pilot cohort and the first and second cohorts of children who participated in the current study showed that the GRS intervention was implemented by teachers, on average, with moderate-to-high fidelity and that most teachers followed the recommended dosage (Noble et al., 2012; Marti et al., 2018a). In addition, 68% of parents attended at least one GRS parent event, and 81% reported spending at least 10–30 min a week doing GRS activities with their children (Marti et al., 2018b).

Supporting Hispanic/Latine children in Head Start

Many of the children Head Start serves are Hispanic/Latine, and current estimates indicate that the number of Hispanic/Latine children in Head Start is rapidly increasing (Vespa et al., 2018; U.S. Department of Health Human Services, 2022). Although not a homogeneous group, Hispanic/Latine children have a unique set of strengths and needs that are important to consider. For example, they are more likely to be dual language learners (DLLs), as Spanish is often spoken in the home. Although Hispanic/Latine children are found to exhibit lower pre-academic skills prior to school entry, research suggests that approaches to learning and executive function may be strengths that Hispanic/Latine bilingual children bring to the classroom (Carlson and Meltzoff, 2008; Galindo and Fuller, 2010; Choi et al., 2018; Bustamante and Hindman, 2020). For these reasons, studies of early interventions should take into account the needs of this population. The GRS intervention was designed to be accessible and responsive to the cultural backgrounds and experiences of Spanish-speaking families.

Current study

The goal of this study was to examine the effects of the GRS intervention on school readiness skills in children in Head Start programs. Participants were 3- and 4-year-olds who were primarily Hispanic/Latine and from Spanish-speaking homes. Specifically,

we examined whether children in the intervention group showed greater gains from pretest to posttest in language/literacy (vocabulary, print knowledge, phonological awareness), early math, and self-regulation (e.g., executive function) compared with children in the Head-Start-as-usual comparison group. We hypothesized that children in the intervention group would demonstrate greater gains in these school readiness skills compared to children in the comparison group.

Methods

Participants

Seven Head Start centers in a large Northeastern city in the U.S. were recruited across three cohorts (2014–2015, 2015–2016, 2016–2017 academic years). Thirty-eight classrooms in these centers participated in the study. Across these 38 classrooms, 31 teachers participated in the study; six teachers participated in the study in the same group (intervention or comparison) in more than one cohort. One classroom was excluded from analyses, as the lead teacher was removed from her position mid-year, resulting in the analysis of 37 classrooms and 30 teachers. Of the families with children in these classrooms, 86% consented to participate; 14% did not have parent/guardian consent to participate in the study.

Parent/child characteristics

Children (46% male) ranged in age from 3.12 to 4.90 years at pretest, and 81% were Hispanic/Latine (10% Black/African American, 2% Asian American, 2% White, and 5% Other/Unspecified). Caregivers who were involved in the study were primarily children's mothers (91%). Fifty-five percent of mothers reported having a high school or lower level of education. There were no significant differences in family or child characteristics between the intervention and comparison groups (see Table 1).

Classroom/teacher characteristics

All classrooms provided full-day preschool. Most teachers were female (97%), Hispanic/Latine (76%), and had a master's degree (71%). They had been teaching for 12 years on average. Head teacher turnover occurred in seven classrooms (intervention group, 5; comparison group, 2). When intervention classroom turnover occurred, new teachers were immediately trained in intervention implementation and received coaching as described below. There were no significant differences in classroom or teacher characteristics between the intervention and comparison groups, except in pretest classroom quality (see Table 2). At pretest, comparison classrooms were rated as significantly higher in overall classroom quality compared to intervention classrooms (see Table 2). Thus, pretest classroom quality was considered for inclusion as a covariate in analyses.

Missing data and attrition

Of the 471 children assessed on at least one school readiness measure at pretest, 435 children were assessed on at least one measure at posttest, resulting in an overall 92% retention rate. The intervention and comparison groups did not differ in this overall retention rate [χ^2 (1, N = 471) = 0.001, p = 0.98]. Children who left the study did not differ significantly from the remaining children in age, family income, sex, or race/ethnicity. The various reasons for this missing data included families leaving the school and children not being available (e.g., school absence) on testing days. Eight families had data missing for the demographic covariates included in the main analyses. Thus, the analytic sample consisted of 463 children included in one or more of the main multilevel models. The main analyses were conducted using multilevel modeling with maximum likelihood estimation to account for missing data (Enders, 2013).

Intervention procedures

Twenty classrooms were assigned to receive the intervention, and 17 were assigned to the Head Start-as-usual comparison group. These assignments were non-random as several Head Start directors chose which teachers would participate in which condition. Six centers used the Creative Curriculum (Dodge et al., 2002) and one used the HighScope curriculum (Michael-Luna and Heimer, 2012); both are whole-child (global) curricula. All study procedures were approved by the Columbia University Medical Center Institutional Review Board. Parents or guardians provided written informed consent for children to participate in this study.

Teacher/classroom component

The GRS classroom curriculum provides supplemental activities promoting emergent literacy, math, and self-regulation skills organized into nine units following a developmentally appropriate sequence. GRS literacy activities include a daily *Morning Message* activity that grows in complexity each unit to target conventions of print and that is integrated in the circle time routine, and stand-alone literacy activities that foster children's acquisition of vocabulary, narrative-building skills, phonological awareness, and print knowledge. To support the acquisition of math skills, GRS includes activities involving one-to-one correspondence, counting, sorting and comparison, pattern identification, and measurement that grow in complexity. To support the development of self-regulation, a set of activities, routines and strategies from the Social Emotional Cognitive Understanding and Regulation (SECURe) curriculum (Jones et al., 2014) was integrated into the GRS curriculum. The preparatory unit of the GRS curriculum includes 6 strategies designed to promote positive interactions between teachers and children and among children. These preparatory activities are meant to be introduced across the first 3–4 weeks of the intervention and then used throughout the intervention (see Supplementary material for details). The curriculum also included nine *Brain Games*: fun, engaging, often-familiar games designed to build executive function skills. Each *Brain Game* has three versions that increase in difficulty and incorporate literacy or math concepts. In addition, the curriculum included one activity per unit that promotes emotional knowledge, expression,

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TABLE 1 Descriptive statistics for parent and child characteristics by condition.

	Intervention		Comparison				
	M	*SD*	*M*	*SD*	*t*	*df*	*p*
Child age at pretest (years)	4.20	0.33	4.17	0.35	0.92	461	0.36
Family income (U.S. dollars)	23,260.70	21,037.60	23,522.70	16,472.70	0.13	361	0.90
	%	*n*	*%*	*n*	χ^2	*df*	*p*
Child sex (male)	42.91	121	50.83	92	2.78	1	0.10
Child race/ethnicity							
Black/African American	10.99	31	8.29	15	3.00	4	0.56
Asian American	2.84	8	1.10	2			
Hispanic/Latine	78.37	221	83.98	152			
White/European American	1.77	5	1.66	3			
Other	6.03	17	4.97	9			
Maternal education							
≤High school diploma/GED	58.44	135	49.66	72	2.78	1	0.10
≥Some college	41.56	96	50.34	73			
Pretest language of assessment							
English	78.57	220	75.69	137	0.52	1	0.47
Spanish	21.43	60	24.31	44			
Posttest language of assessment							
English	88.55	232	85.71	144	0.75	1	0.39
Spanish	11.45	30	14.29	24			
Language spoken in the home							
All or primarily English	41.10	97	46.50	73	1.89	2	0.39
All or primarily Spanish	34.32	81	34.39	54			
Half English and half Spanish	24.58	58	19.11	30			
Child's dominant language (parent-report)							
English	60.68	142	60.93	92	0.99	2	0.61
Spanish	27.78	65	30.46	46			
Both	11.54	27	8.61	13			

There was some variability in sample sizes for these characteristics due to variability in parental completion of questionnaires.

management, and cooperation by using books available in the classroom.

Each GRS activity has a description of materials required, vocabulary to use, core concept being targeted, recommended group size, and step-by-step lesson plan with teaching practice tips. All materials required are either present in the class (e.g., blocks, paper, markers) or are provided by the GRS team. For example, GRS includes 29 posters to use in circle time or small group that target specific literacy and math activities.

Following a full-day introductory training, teachers received weekly individualized meetings with a coach, alternating between planning and observation. During planning meetings, teachers selected GRS activities to use in the ensuing 2 weeks and reflected on previously implemented activities. Coaches and teachers selected 4–5 activities from a menu of activities (i.e., language/literacy, math, self-regulation) organized by difficulty for each of the two following weeks, including one each of the following: *Morning Message*, *Brain Game* (self-regulation, repeated daily), math activity, language/literacy activity, and additional activity. During observation meetings, coaches observed teacher implementation of activities and modeled live-support as needed (Marti et al., 2018a).

Parent/home component

The GRS parent/home component consists of a series of activities following a developmentally appropriate sequence aligned with the sequence of the classroom activities. The activities can be easily completed using simple household materials and are designed to be integrated into daily family routines and be done at home or in the neighborhood (see Supplementary material for details). At the beginning of the intervention, parents were invited

TABLE 2 Descriptive statistics for classroom and teacher characteristics by condition.

	Intervention		Comparison				
	M	*SD*	*M*	*SD*	*t*	*df*	*p*
Student-teacher ratio	8.11	1.88	7.17	2.00	1.47	35	0.15
Teacher age (years)	37.94	9.19	44.09	11.87	1.52	25	0.14
Early childhood teaching experience (years)	11.58	7.54	14.60	7.46	1.05	26	0.30
Teacher time at the current center (years)	6.06	8.55	8.49	8.23	0.77	27	0.45
Pretest classroom quality	4.65	0.80	5.18	0.52	2.34	35	0.02
Teacher sex (female)	100.00	14	93.75	15	0.91	1	0.34
Teacher ethnicity (Hispanic/Latine)	85.71	12	66.67	10	1.43	1	0.23
	%	*n*	*%*	*n*	χ^2	*df*	*p*
Type of classroom							
All 4-year-olds	65.00	13	52.94	9	0.55	1	0.46
Mixed 3- and 4-year-olds	35.00	7	47.06	8			
Head teacher turnover	25.00	5	11.76	2	1.05	1	0.31
Teacher education							
Associate's degree	7.14	1	7.14	1	0.87	2	0.65
Bachelor's degree	28.57	4	14.29	2			
Master's degree	64.29	9	78.57	11			

There were 37 total classrooms and 30 total teachers in this study.

to attend a GRS orientation/kickoff event and received a workbook with instructions and a set of materials to use (Marti et al., 2018b). Parents were then invited to subsequent in-person GRS parent workshops and classroom events. Parents were sent text message reminders to attend GRS events. Each classroom had one tablet containing GRS videos showing real parents doing the learning activities with their children and a voice-over giving tips on how to do the activity. Parents were allowed to take the tablet home for a week at a time. Videos are available in Spanish and English and were designed for culturally diverse parents and parents with low levels of literacy. During the 2015–2016 cohort, some parents received an additional intervention aimed at increasing parental engagement in the GRS intervention (Gennetian et al., 2019). Cohort was included as a covariate in all analyses in the current study.

Classroom coaches and parent workshop leaders received extensive training and supervision by the project's principal investigators. Classroom coaches and parent workshop leaders held, or were pursuing, a master's or doctoral degree in education or psychology.

School-home connection

Aligning school and home GRS components, teachers provided parents with weekly letters suggesting activities from the program activity book to be done at home based on activities that were being used in the classroom. Intended to improve parent-teacher communication, parent engagement, and to support parents in their interactions with their child, the letter format and content changed across the intervention. The letter was accompanied by an activity tracker, giving parents the opportunity to provide feedback to teachers. Additionally, teachers were invited to participate in the parent kickoff event and in two GRS classroom parties, reinforcing the home-school connection.

Assessment procedures

At pretest (start of the fall semester) and posttest (end of the spring semester), GRS staff administered school readiness tasks to children. There was an average of 7 months between pretest and posttest, and time between pretest and posttest was considered for inclusion as a covariate in analyses. At each timepoint, children completed two 20- to 30-min testing sessions on different days. Tasks were administered to children by bilingual assessors in a fixed order. Additionally, parents completed demographic questionnaires, which included items on maternal education, family income, child race and ethnicity, and language spoken in the home.

Language of assessment

Children who spoke both Spanish and English, as reported by parents and/or teachers, were assessed for language dominance at pretest and posttest to determine assessment language. The Preschool Language Assessment Scale (PreLAS) Simon Says (10 items), Art Show (10 items), and Say What You Hear (10 items) subtests (DeAvila and Duncan, 2000) were administered to children in English and Spanish. The PreLAS demonstrates strong reliability and validity as a language screening measure (Rainelli et al., 2017; Aikens et al., 2020). Children were then administered versions of the school readiness assessments in the higher-scored language. The intervention and comparison groups did not differ significantly in the proportion of children assessed

in English or Spanish at pretest or posttest, language spoken in the home, or parent-reported child dominant language (see Table 1 and Supplementary material).

Measures

Language/literacy

Vocabulary

Expressive vocabulary was measured in cohorts 2 and 3 using the Expressive One-Word Picture Vocabulary Test (EOWPVT-Fourth Edition) (Martin and Brownell, 2011). Spanish-dominant children completed the EOWPVT-Spanish Bilingual Edition (EOWPVT-SBE) (Martin, 2012). Children are asked to use one word to label pictures of objects, actions, concepts, or categories. For example, children taking the EOWPVT were asked to verbally respond to prompts such as "What is this?", "What is she doing?", and "What are these?". In previous studies, internal consistency for the EOWPVT has ranged from 0.93 to 0.98 (Martin and Brownell, 2011).

Print knowledge

Print knowledge was measured using the Letter-Word Identification subtest of the Woodcock-Johnson Tests of Achievement-Third Edition (WJ) (Woodcock et al., 2001). Spanish-dominant children completed the Identificación de Letras y Palabras subtest of the Bateria III Woodcock-Muñoz Pruebas de Aprovechamiento (Munoz-Sandoval et al., 2005). These subtests involve identifying printed letters and reading printed words aloud (e.g., "car"). In previous reports, internal consistency (Cronbach's alpha) for these subtests ranged from 0.81 to 0.98. Test-retest reliability ranged from 0.89–0.92 (Bradley-Johnson et al., 2004). Pretest and posttest scores on this measure were log-transformed to correct for positive skew.

Phonological awareness

Phonological awareness was measured using the Phonological Awareness subtest of the Clinical Evaluation of Language Fundamentals-Preschool-Second Edition (CELF-P2) (Semel et al., 2003). Spanish-dominant children completed the Conocimiento Fonológico subtest of the CELF-P2-Spanish. These subtests assess rhyming, blending, segmenting, and identifying sounds and syllables (e.g., "Tell me a word that rhymes with hat"). Sections that matched across the English and Spanish versions were used in analyses; children's scores from these sections were summed, creating a total score. In previous research, the CELF-P2 Phonological Awareness subtest demonstrated test-retest reliability of 0.82–0.86, Cronbach's alpha of 0.88; the CELF-P2-Spanish version demonstrated test-retest reliability of 0.81–0.93, internal consistency of 0.82–0.88 (Semel et al., 2003).

Early math

Quantitative reasoning

Quantitative reasoning was assessed using the Applied Problems subtest of the Woodcock-Johnson Tests of Achievement-Third Edition (Woodcock et al., 2001). Spanish-dominant children completed the Problemas Aplicados subtest of the Batería III Woodcock-Muñoz Pruebas de Aprovechamiento (Munoz-Sandoval et al., 2005). These subtests ask children to analyze and solve math problems. Previous studies support the reliability of this measure (e.g., Cronbach's alpha ranged from 0.90–0.92) (Bradley-Johnson et al., 2004).

Early math

Early math skills were assessed using the 19-item Research-based Early Math Assessment-Short Form (REMA-SF) (Clements et al., 2008; Weiland et al., 2012) in cohorts 2 and 3 only. Spanish-dominant children completed the Spanish version of the REMA-SF. Test items require children to engage in comparing and ordering, verbal counting, arithmetic, number recognition, shape identification, shape composition, and patterning. Normed for preschool children, the REMA-SF demonstrates evidence of validity and reliability. In a previous report, internal consistency ranged from 0.75 to 0.94 (Clements et al., 2008). Similarly, in our sample, internal consistency was adequate (pretest $\alpha = 0.77$; posttest $\alpha = 0.76$).

Self-regulation

Executive function

The Head-Toes-Knees-Shoulders (HTKS) task (Ponitz et al., 2009; McClelland et al., 2014) was used to measure the integration of multiple executive function skills. This task includes three sections of 10 items each (30 total test items), with practice items preceding test items in each section. In each section, children are presented with a paired behavioral rule and asked to do the opposite of what the assessor says. First, they are told to touch their head when the assessor says to touch their toes and vice versa (10 items). If they get four or more items correct, they are given 10 additional items with two paired rules (e.g., touch your head/touch your toes, touch your knees/touch your shoulders), then 10 more items in which the paired rules are switched (e.g., touch your head/touch your knees, touch your shoulders/touch your toes). On each item, children receive 2 points for responding correctly, 1 point for self-correcting, and 0 points for responding incorrectly. Possible total scores range from 0 to 60, with higher scores indicating higher self-regulation. The HTKS task demonstrates good construct and predictive validity in both English- and Spanish-speaking samples (McClelland et al., 2007, 2014; Ponitz et al., 2009). In past studies, inter-rater reliability has been consistently high, and internal consistency estimates are reported as above 0.80 (Montroy et al., 2016). HTKS task scores were log-transformed to correct for positive skew.

Inhibitory control

The Preschool Self-Regulation Assessment (PSRA) toy wrap task (Kochanska et al., 2000; Smith-Donald et al., 2007) was used to measure inhibitory control, a core executive function component. This task requires inhibitory control in the context of a reward (Garon et al., 2008). In this task, the child is told they will be receiving a present and is asked not to peek while the assessor noisily wraps the present for 1 min. The latency score used in analyses reflects time elapsed before the child peeked. The toy wrap task demonstrates strong evidence of reliability and validity (Smith-Donald et al., 2007; Raver et al., 2011).

Attention/impulse control

After each testing session, assessors completed the PSRA Assessor Report (Smith-Donald et al., 2007). The Attention/Impulse Control factor (10 items) provides a global picture of concentration, patience, distractibility, focus, planning, compliance, and ability to be seated during evaluation (e.g., "Pays attention during instructions and demonstrations"). Items are coded using a Likert scale ranging from 0 to 3, with some items reverse-coded to minimize automatic responding. Attention/Impulse Control scores were averaged across the two testing sessions at each timepoint (pretest and posttest). Internal consistency of the Attention/Impulse Control factor has previously been reported as strong ($\alpha = 0.89$) (Smith-Donald et al., 2007) and was also strong in the current study (pretest session 1 $\alpha = 0.91$; pretest session 2 $\alpha = 0.89$; posttest session 1 $\alpha = 0.87$; posttest session 2 $\alpha = 0.89$).

Classroom quality

Classroom quality was measured using the Classroom Assessment Scoring System (CLASS) (Pianta et al., 2008; Hamre et al., 2014). Certified CLASS coders observed classrooms for four 20-minute cycles at pretest and posttest. In each cycle, teacher-child interaction quality was assessed in 10 dimensions within three domains: Emotional Support (Positive Climate, Negative Climate, Teacher Sensitivity, Regard for Student Perspectives), Classroom Organization (Behavior Management, Productivity, Instructional Learning Formats), and Instructional Support (Concept Development, Quality of Feedback, Language Modeling). Each dimension is scored on a 7-point scale ranging from 1 (low) to 7 (high). Strong internal consistency was found for the CLASS total score in the current sample ($\alpha = 0.80$). Pretest classroom quality total scores, calculated by averaging the pretest domain scores, were used in analyses.

Statistical analyses

All analyses were conducted in SAS (version 9.4) (SAS Institute, Cary, NC). Multilevel modeling was used to examine whether the GRS intervention improved children's school readiness skills. Children were nested within classrooms ($M = 14$ children per classroom, $SD = 3.67$) within Head Start centers ($N = 7$). Most outcome variables exhibited variability at the classroom level, with intraclass correlations (ICCs) ranging from 0.00 to 0.16 ($p = 0.002$–0.19; see Supplementary Table S1). Head Start center-level variances of posttest outcome measures ranged from 0.00–0.11 ($p = 0.07$–0.18). In total, repeated observations (level 1) were nested within children (level 2) who were nested within classrooms (level 3) within Head Start centers (level 4). Initial analyses including Head Start center (dummy-coded; $N = 7$) as a covariate indicated nonsignificant effects; thus, Head Start center was not included in the final models. Therefore, multilevel models specifying random child- and classroom-level intercepts were conducted to account for nesting within children and classrooms (Raudenbush and Bryk, 2002). These analyses were conducted using the mixed procedure and restricted maximum likelihood estimation with Kenward-Roger degrees of freedom. Using this analytic approach, children with complete data for the predictor variables were included in analyses even if they had missing data for the outcome variable.

Children's school readiness outcomes (eight total) were modeled as a function of group (intervention, comparison), time (pretest, posttest), and the group-by-time interaction. Separate models were run for each outcome (three early language/literacy, two early math, and three self-regulatory skills). Age, sex, race/ethnicity, and cohort were included as covariates. The group-by-time interaction is key to understanding whether change over time differed for the intervention group compared to the comparison group (or whether the effect of the intervention was different at pretest compared to posttest). Although we initially included time between pretest and posttest and pretest classroom quality as covariates, they did not significantly contribute to the final estimates and were removed from the models for parsimony. False discovery rate (FDR) corrections (Benjamini and Hochberg, 1995) were used to control for multiple comparisons within each school readiness domain (DiPerna et al., 2018; U.S. Department of Education, 2021).

Effect size (ES) for intervention effects was calculated as a Cohen's *d* type statistic, based on the difference between posttest means that were adjusted for pretest (and other child- and classroom-level covariates), then divided by the pooled pretest group standard deviations (Bierman et al., 2015; Landry et al., 2017, 2019; DiPerna et al., 2018). Cohen's *d* statistics around 0.20, 0.50, and 0.80 represent small, medium, and large effects, respectively (Cohen, 1992).

Results

Descriptive statistics for children's school readiness scores are presented in Table 3, and zero-order correlations are presented in Supplementary Table S2.

Pretest differences in school readiness

The intervention and comparison groups did not differ significantly at pretest in vocabulary ($p = 0.31$), print knowledge ($p = 0.20$), phonological awareness ($p = 0.09$), quantitative reasoning ($p = 0.55$), early math skills ($p = 0.51$), executive function ($p = 0.06$), inhibitory control ($p = 0.34$), or attention/impulse control ($p = 0.15$).

Intervention effects on language/literacy

The group-by-time interaction was significant for vocabulary, as measured by the EOWPVT, and print knowledge, as measured by the WJ Letter-Word Identification subtest (see Table 4). Vocabulary and print knowledge significantly increased over time in both groups but increased more steeply among children in the intervention group (see Figure 1). At posttest, compared to children in the comparison group, children in the intervention group had significantly higher vocabulary, $t(27.4) = 2.48$, $p = 0.02$, ES =

TABLE 3 Descriptive statistics for school readiness scores by condition and time point.

	Intervention						Comparison					
	Pretest			Posttest			Pretest			Posttest		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Language/literacy												
EOWPVT	164	41.24	13.80	148	53.63	15.16	102	38.98	14.99	86	47.39	15.16
WJ letter-word identification	278	6.55	5.20	258	9.39	5.76	179	7.14	5.26	166	9.51	6.24
CELF phonological awareness	271	4.81	3.53	250	7.54	3.11	171	5.39	3.60	160	7.66	3.33
Early math												
WJ applied problems	279	8.76	4.23	259	13.28	4.11	178	9.08	4.37	164	12.64	4.35
REMA-SF	180	8.23	3.68	163	12.29	4.03	108	8.58	4.05	90	11.51	4.09
Self-regulation												
HTKS	277	5.09	10.44	257	15.61	16.98	178	7.32	12.95	165	17.61	17.55
PSRA toy wrap	263	34.36	24.13	231	40.58	23.31	168	35.82	23.47	144	43.01	22.91
PSRA attention/impulse control	278	23.02	5.32	259	23.71	4.97	181	23.82	5.16	168	24.31	4.59

Letter-word identification and HTKS task scores were log-transformed for analyses. Descriptive statistics for the original values are shown here for ease of interpretation.
EOWPVT, Expressive One-Word Picture Vocabulary Test; WJ, Woodcock-Johnson Tests of Achievement; CELF, Clinical Evaluation of Language Fundamentals-Preschool; REMA-SF, Research-based Early Math Assessment- Short Form; HTKS, Head-Toes-Knees-Shoulders; PSRA, Preschool Self-Regulation Assessment.

0.34, but not print knowledge, $t(33.4) = 0.39$, $p = 0.70$, ES = 0.03. Adjusted means across groups are presented in Table 4. There were no significant effects for phonological awareness. Full results of the final models are provided in Supplementary Table S3.

Intervention effects on early math

The group-by-time interaction was significant for quantitative reasoning, as measured by the WJ Applied Problems subtest, and early math skills, as measured by the REMA-SF (see Table 4). Quantitative reasoning and early math skills significantly increased over time in both groups but increased more steeply among children in the intervention group (see Figure 2). The groups did not differ significantly in quantitative reasoning, $t(39.5) = 0.93$, $p = 0.36$, ES = 0.12, or early math skills, $t(36.2) = 1.20$, $p = 0.24$, ES = 0.19, at posttest. Full results of the final models are provided in Supplementary Table S4.

Intervention effects on self-regulation

There were no significant group-by-time interactions for scores on the HTKS or toy wrap tasks or assessor-reported attention/impulse control (see Table 4). Full results of the final models are provided in Supplementary Table S5.

Sensitivity analyses

The group-by-time interactions for vocabulary, print knowledge, quantitative reasoning, and early math remained significant after additionally controlling for pretest and posttest assessment language. In addition, there were no significant interactions between group and cohort or between group and classroom age (all 4-year-olds versus mixed 3- and 4-year-olds).

Discussion

The goal of this study was to examine the impact of the GRS intervention on school readiness among children in Head Start programs. The GRS intervention provided a supplemental skill-based curriculum that targeted early language/literacy, math, and self-regulation through aligned classroom and home components. Professional development and coaching were provided to teachers to support their daily use of instructional activities as part of the normal classroom routine (Marti et al., 2018a). Parents were invited to workshops and events, received a workbook and letters from the teacher, and were provided with access to training videos to support their use of GRS activities at home with their children (Marti et al., 2018b). Across the eight outcome variables, the intervention group showed significantly steeper increases over time in four—two language/literacy and two early math skills—compared to the Head-Start-as-usual comparison group. Intervention effects were not observed for self-regulation.

Intervention effects on pre-academic skills

In the language and literacy domain, compared to children in the comparison group, children in the intervention group made greater gains over time in vocabulary and print knowledge but not phonological awareness. At posttest, the intervention group had significantly higher vocabulary skills than the comparison group, with a small-to-medium effect size. Group differences in print knowledge and phonological awareness at posttest were not significant. In addition, the intervention group made significantly

TABLE 4 Adjusted means at posttest across groups and results of multilevel models.

	Adjusted means		Group		Time		Group-by-time interaction		
	Intervention	Comparison	*b*	*p*	*b*	*p*	*b*	*p*	FDR-corrected *p*
Language/literacy									
EOWPVT	55.72	50.83	1.86	0.34	9.01	<0.001	3.02	0.01	0.02
WJ letter-word identification	1.03	1.02	−0.04	0.22	0.12	<0.001	0.05	0.01	0.02
CELF phonological awareness	7.93	8.03	−0.62	0.14	2.17	<0.001	0.36	0.15	0.15
Early math									
WJ applied problems	13.56	13.04	−0.41	0.47	3.44	<0.001	0.93	0.004	0.01
REMA-SF	12.31	11.59	−0.36	0.53	2.90	<0.001	1.07	0.03	0.03
Self-regulation									
HTKS	0.90	0.98	−0.10	0.05	0.45	<0.001	0.03	0.68	–
PSRA toy wrap	39.67	43.88	−2.44	0.29	7.70	<0.001	−1.77	0.53	–
PSRA attention/impulse control	23.59	24.23	−0.96	0.07	0.36	0.34	0.31	0.52	–

All analyses included random intercepts at the child and classroom level and controlled for age, sex, race/ethnicity, and cohort.
False discovery rate (FDR) corrections were used to control for multiple comparisons within each school readiness domain.
EOWPVT, Expressive One-Word Picture Vocabulary Test; WJ, Woodcock-Johnson Tests of Achievement; CELF, Clinical Evaluation of Language Fundamentals-Preschool; REMA-SF, Research-based Early Math Assessment- Short Form; HTKS, Head-Toes-Knees-Shoulders; PSRA, Preschool Self-Regulation Assessment; –, not applicable.

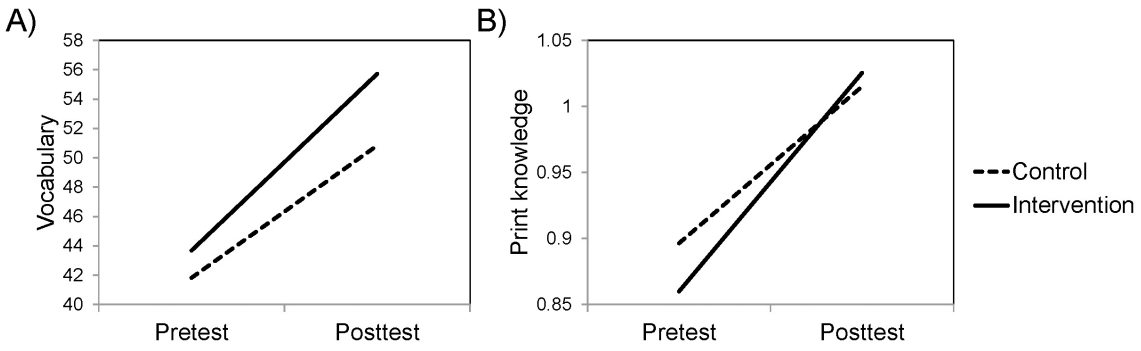

FIGURE 1
Changes over time in language/literacy skills across groups. Increases in **(A)** vocabulary and **(B)** print knowledge were steeper in the intervention group compared to the comparison group.

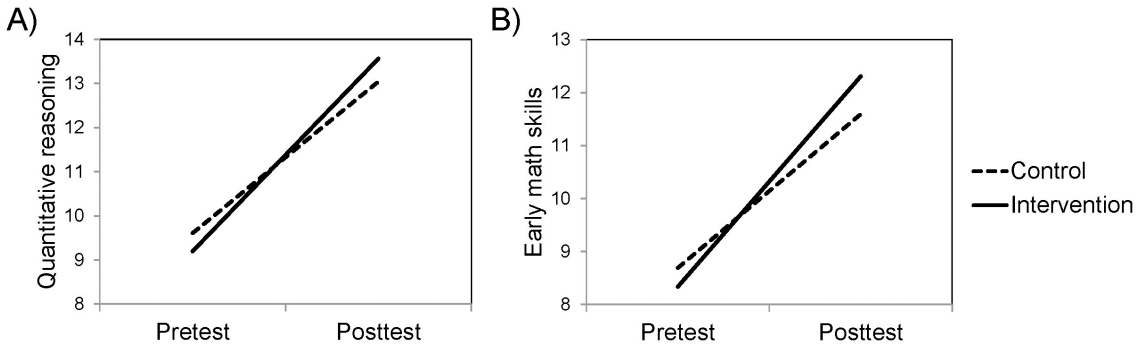

FIGURE 2
Changes over time in early math skills across groups. Increases in **(A)** quantitative reasoning and **(B)** early math skills were steeper in the intervention group compared to the comparison group.

greater gains over time in early math compared to the comparison group. Although not statistically significant, the intervention group scored higher in early math at posttest than the comparison group, with a small effect size. It is recommended that effect sizes be considered in conjunction with statistical significance (Wasserstein and Lazar, 2016). Thus, results were strongest for vocabulary but encouraging for early literacy and math skills, as the intervention group exhibited greater gains over time in these skills compared to the comparison group.

Results for vocabulary, and to a lesser extent early literacy and math, are consistent with previous work. For example, skill-based curricula targeting early language/literacy have been found to improve oral language in children in Head Start programs (Jenkins et al., 2018; Joo et al., 2020). Increases in vocabulary may lead to increases in other school readiness skills, as oral language development can be a precursor to developmental advances in other domains (Purpura et al., 2011).

It is not possible to pinpoint what may be driving this intervention effect. One possibility is that the structure and content of GRS activities may have encouraged teachers and parents to engage in more enriching conversations and use new vocabulary, which improved children's vocabulary skills. In addition, the individualized weekly coaching teachers received may have been a key feature of the intervention. Another contributing factor may have been the linguistic and cultural responsiveness of the intervention, as all GRS materials were designed to be culturally sensitive, were pilot tested in bilingual classrooms, and home activities and videos for parents were translated into Spanish (Marti et al., 2018a,b). Our methods, though, do not allow insights into the extent to which the classroom or parent component of the intervention was responsible for improvements in language and early math.

The overall pattern of results for pre-academic skills suggests that the GRS intervention could have positive impacts on early language/literacy and math, two core school readiness domains. There was a pattern of increases over time in pre-academic skills favoring the intervention group. Although some content-specific interventions targeting early math or literacy/language skills have demonstrated spillover effects on other pre-academic skills that were not targeted by the intervention, these effects have not been consistently observed (Sarama et al., 2012). The current results are consistent with the idea that content-specific interventions targeting both early language/literacy and math may improve both early language/literacy and math but prompt further discussion about possible adjustments to the intervention that could make it more effective.

Possible explanations for non-significant results

Although the results for pre-academic skills are encouraging, the GRS intervention did not significantly improve children's self-regulatory skills. Thus, taken together, it is important to consider why the intervention was not more effective. One possibility is that increased teacher and parent use of the GRS activities may have led to greater improvements in school readiness skills in children. Although teachers implemented the intervention with moderate-to-high fidelity (dosage, adherence fidelity) on average, there was variability in intervention fidelity across classrooms (Marti et al., 2018a). Higher intervention fidelity in the classroom was associated with greater gains in early literacy, math, and self-regulation among children (Marti et al., 2018a). Some teachers may have needed more intensive professional development and coaching to implement the intervention with higher fidelity. Similarly, prior results indicated variability in parental involvement in the GRS intervention (Marti et al., 2018b). Greater parental involvement in the intervention was significantly associated with greater gains in children's early literacy, math, and self-regulatory skills (Marti et al., 2018b). Thus, greater parental engagement, and more support for parental use of GRS activities at home, may have led to greater gains in school readiness skills. Many early interventions have reported facing challenges with parental engagement, as low access to socioeconomic resources and other factors make it difficult for parents to enroll and participate in parent programs and interventions (Gennetian et al., 2019). Future studies should focus on effective strategies to increase parental engagement (Bierman et al., 2023).

Another possibility is that providing activities targeting all three school readiness domains may have been demanding for teachers in terms of instructional time and organization, and this may have reduced the intensity and frequency of certain GRS activities. Although evidence suggests that teachers' completion rates did not vary across language/literacy, early math, and self-regulation activities (Marti et al., 2018a), teachers may have spent less time on self-regulation activities than early literacy and math activities, yielding lower impacts. However, our intervention fidelity measures did not allow us to test this possibility, as we did not measure time spent on activities in each school readiness domain. In addition, our intervention fidelity measures did not capture the repetition of activities.

Finally, some interventions found to improve children's self-regulation have focused on improving classroom management as a means of improving self-regulation. For example, some interventions that emphasized providing teachers with professional development and coaching on classroom management have significantly improved children's self-regulation (Raver et al., 2011; Morris et al., 2013). Thus, further integrating enhanced teacher professional development to improve classroom organization and management into the GRS intervention may lead to significant gains in children's self-regulation (Lonigan et al., 2015). This approach may be especially effective if paired with a parenting-focused component (Bierman et al., 2023). Future research should use a randomized controlled design to examine whether a modified version of the GRS intervention leads to more pervasive increases in school readiness skills with larger effect sizes.

Linguistic and cultural considerations

Most children in this study were Hispanic/Latine DLLs. Many children who are DLLs exhibit significant delays in their language and early literacy skills in preschool. Research suggests that teachers need specific support and instructional strategies to address early

literacy skills in this population (Zepeda et al., 2011; Jacoby and Lesaux, 2017). The GRS intervention did not provide teacher training on specific strategies to meet the learning needs of DLLs. Research is beginning to identify specific intervention approaches with teacher professional development components that bolster early literacy skills in DLLs (Buysse et al., 2010; Larson et al., 2020). For example, early interventions that emphasize small-group, bilingual language and early literacy instruction have been found to increase language and literacy skills in DLLs (Méndez et al., 2015; Landry et al., 2019). Although a strength of the GRS intervention is its linguistic and cultural responsiveness, future versions of the intervention should further adapt the classroom component to Hispanic/Latine DLLs, who are increasingly served by Head Start programs.

Strengths and limitations

This study had a number of strengths. GRS is an evidence-informed early intervention that involved a skill-based supplemental curriculum, support for learning in the home environment, and professional development and coaching for teachers. Most of the children who participated in this longitudinal study were Hispanic/Latine, one of the fastest growing populations in the U.S. (Vespa et al., 2018), increasingly served by Head Start (U.S. Department of Health Human Services, 2022) and understudied. Strengths of this study also included the use of direct assessments of multiple school readiness skills and use of the PreLAS as a routing measure to determine language dominance in DLLs. This study also had a high retention rate from pretest to posttest and a rigorous analytic approach.

This study also had limitations that should be considered when interpreting the findings. First, we employed a non-randomized, quasi-experimental design, limiting our ability to make causal inferences. There were no significant group differences in most classroom, teacher, and family characteristics, or pretest school readiness skills. However, comparison classrooms were rated higher in quality than intervention classrooms at pretest. Second, implemented self-regulation measures may not have captured all the specific components of self-regulation that the intervention targeted. Indeed, some previous intervention studies have demonstrated effects specific to certain executive function components or measures (Bierman et al., 2014). Psychometric issues with the self-regulation measures, such as floor effects with the HTKS task (Gonzales et al., 2021), may also have affected the results for self-regulation. Third, in 2016, universal pre-kindergarten was being rolled out, and most Head Start classrooms were participating in some capacity during the study. Although we accounted for potential classroom and cohort effects, pre-kindergarten was not implemented equally across centers. Thus, unmeasured variables such as teachers across the intervention and comparison classrooms implementing Department of Education recommended curricula or Units of Study may have presented a confounding factor of intervention effects. Fourth, to capture the full development of school readiness skills in DLLs, children need to be assessed in both languages (Peña and Halle, 2011; Méndez et al., 2019; Guzman-Orth et al., 2017). Therefore, testing DLLs in both languages may have led to more comprehensive insights into their school readiness skills. Fifth, some of the classroom observations were conducted by GRS staff who were certified CLASS observers.

Conclusion

This study is the first to examine the effects of the GRS intervention, a content-specific curriculum that targeted language/literacy, math, and self-regulation through aligned classroom and home components, on school readiness skills among children in Head Start programs. Children in the intervention group exhibited steeper increases over time in early language/literacy and math skills, and had significantly higher vocabulary skills at posttest, compared to those in the comparison group. Despite these encouraging results for pre-academic skills, intervention effects were not found for self-regulation. Key features of the GRS intervention were increasing support for learning in both the classroom and home environments and using an integrated curriculum targeting core school readiness skills. Interventions that use and build on this approach may support the development of school readiness skills in children from socioeconomically under-resourced families.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Columbia University Medical Center Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

MM-C: Conceptualization, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. EM: Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. CW: Writing – original draft, Writing – review & editing. SM: Methodology, Project administration, Writing – original draft, Writing – review & editing. KH: Supervision, Writing – original draft, Writing – review & editing. CL: Conceptualization, Writing – original draft, Writing – review & editing. KN: Conceptualization, Funding acquisition, Methodology, Project administration, Writing – original draft, Writing – review & editing. HD: Conceptualization,

Funding acquisition, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fdpys.2024.1477476/full#supplementary-material

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