PREDICTORS OF KINDERGARTEN SCIENCE ACHIEVEMENT AND ITS GROWTH ACROSS ELEMENTARY SCHOOL FOR MULTILINGUAL AND ENGLISH MONOLINGUAL LEARNERS

ABSTRACT

Using the Early Childhood Longitudinal Study Kindergarten Cohort (2010–2011), this study is the first to investigate predictors of kindergarten science achievement and growth across elementary school—English language proficiency (ELP), executive functioning, math and reading achievement, parent-engaged science and math activities, and classroom science content coverage—separately for multilinguals ($n = 1{,}023$) and English monolinguals ($n = 12{,}329$). Multigroup latent growth curve models indicate initial differences in science are largely explained by the group of predictors, multilinguals learn science more rapidly in early elementary school than English monolinguals, and science scores are not meaningfully different between the fifth-grade groups. Among other notable results, ELP predicts science growth for both groups and math achievement predicts science growth for multilinguals only; reading achievement only predicts growth for English monolinguals. The findings from this study strongly challenge the prevailing belief that being multilingual in the United States leads to poor achievement.

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To develop a globally competitive workforce, there has been increased emphasis on developing students' science skills in the United States (Committee on STEM Education, National Science and Technology Council, 2013). The average science score for US students is, however, decreasing rather than increasing (Mullis et al., 2020; National Center for Education Statistics [NCES], 2019) with the majority of students not demonstrating competency of subject matter in physical science, life science, and earth and space sciences (NCES, 2019). This issue may be exacerbated among US students from nondominant backgrounds as they are more likely to receive poor-quality childcare and educational experiences (Flores, 2007), which manifests as achievement inequities by kindergarten (Galindo, 2010; Greenfield et al., 2009). Thus, science achievement gaps emerge early and are persistent, but they may be explained by malleable factors (Morgan et al., 2016). To close science achievement gaps, a stronger understanding of the factors associated with early science achievement and growth across elementary school is needed. Few studies have focused on science, technology, and engineering (referred to as "science" herein) among students in US elementary schools. Even fewer (if any) studies have investigated science growth trajectories and factors predictive of science learning for multilingual children. For this study, multilingual children are defined as students whose primary home language is not English and includes children who are bilingual or have varying degrees of proficiency in more than one language, with English being a nonnative language for them (O'Neal & Ringler, 2010; Park et al., 2018).

The current understanding of multilinguals' development (e.g., science) is limited (Castro, 2014). There is a need to gain a better understanding of malleable factors that support early science learning for multilinguals. Best practices call for researchers to shift away from assuming that multilinguals' development and associated factors are the same as for monolinguals (Castro, 2014). To address these limitations of the extant research, the present study seeks to gain a stronger understanding of the factors associated with science achievement and growth among multilinguals in US elementary schools.

Theoretical Framework

Science achievement is a multifaceted construct that encompasses both scientific thinking and conceptual understanding (Lehrer & Schauble, 2015). Scientific thinking refers to the ability to generate, test, and evaluate hypotheses and data and is a critical aspect of scientific inquiry (e.g., Bullock et al., 2009; Morris et al., 2012). Conceptual understanding, on the other hand, is the accumulation of factual knowledge and conceptual descriptions of why things occur (Carey, 1985; Gopnik, 2003; Morgan et al., 2016). Both components are essential for science achievement and are influenced by a variety of factors, including cultural practices.

The cultural adapted bioecological model of human development, as described by Vélez-Agosto et al. (2017), provides a theoretical framework for understanding the role of culture in shaping children's microsystems, including their learning experiences at home and in school. This model posits that cultural practices are central to human development and that families and teachers organize children's learning experiences in ways that contribute to their academic achievement. Importantly, the model suggests that cultural practices may differ for multilinguals and English monolinguals, which may affect the relations between child characteristics, home learning environment, classroom instruction, and science achievement (Vélez-Agosto et al., 2017). This highlights the need to consider language background when examining the factors that contribute to science achievement among diverse student populations. By taking a holistic approach to understanding these factors, educators can better support the diverse needs of their students and promote science achievement for all.

Child Characteristics

Language Proficiency

Language proficiency is identified as a crucial factor for children to understand science concepts, express their metaconceptual understanding of science knowledge (Koerber & Osterhaus, 2019), and engage in complex (i.e., scientific) reasoning (Amsel et al., 2008). In addition, science is generally regarded as having a specialized language (as is math) with its own technical vocabulary, including everyday language that has a specific meaning when used in the context of science (Mullis et al., 2013). Children's English language proficiency (ELP) is associated with and predicts their science achievement across early elementary school for multilinguals and English monolinguals even after accounting for socioeconomic status (SES), cognitive ability, and immigrant status (Decristan et al., 2016; Foster et al., 2022; Maerten-Rivera et al., 2010). Whether the relationship between language proficiency and science achievement growth is the same for multilingual and English monolingual children within the US educational context, however, is unknown.

Executive Functioning

Executive functioning (EF) is a set of cognitive abilities (i.e., inhibitory control, working memory, and cognitive flexibility) that are crucial for managing and allocating cognitive resources during cognitively challenging activities (Diamond, 2013; Pascual-Leone & Johnson, 2021). EF is essential for sustained attention, problem-solving, planning, critical thinking, goal-oriented behavior, and task perseverance, and is related to math and reading achievement (e.g., Bull et al., 2008; Cirino et al., 2018; McClelland et al., 2015). Emerging research suggests that EF is related to science achievement, predicting its development during elementary school (Anthony & Ogg, 2019; Foster et al., 2022; Morgan et al., 2019). EF abilities may aid children in engaging in the complex reasoning required for science, which involves testing and evaluating hypotheses (Amsel et al., 2008; Gropen et al., 2011; Koerber & Osterhaus, 2019). Finally, bilingualism, a continuum of experiences in two or more languages, may be associated with EF advantages (Bialystok & Shorbagi, 2021; Leon Guerrero et al., 2016), but the findings are inconsistent. It is possible that multilingual experiences confer advantages for science achievement among multilinguals.

Math Achievement

Improvements in students' math skills were associated with increases in science achievement among multilingual and monolingual students in elementary school

(Foster et al., 2022; Maerten-Rivera et al., 2010). Math may provide the language and tools necessary to understand science concepts and applications, and science may provide the context for demonstrating mathematical patterns and relationships (Batista & Matthews, 2002; Maerten-Rivera et al., 2010). Given that math and science both require advanced metacognitive processing including problem-solving and critical-thinking skills, which have been shown to be advanced in bilingual learners (Abu Rabia, 2019; Bialystok & Craik, 2010; Bialystok et al., 2012), multilinguals may rely more heavily on their math skills than monolinguals when solving science problems administered in English. Particularly, multilingual learners rely on metacognitive skills as they consider skills they have acquired across languages, applying their cultural knowledge to instructional tasks (Morales & DiNapoli, 2018). Multilinguals must depend on this underlying knowledge across languages when engaging in the complex cognitive processing and strategy use prevalent in the discursive practices of scientific fields as taught within math and science curricula (Domínguez, 2011; Poza, 2015). As a result, a focus on improving math skills, including increasing knowledge in strategy use and critical thinking within the context of science instruction to assist struggling students, may help learners understand science concepts, especially for multilinguals.

Reading Achievement

On average, students who struggle with reading learn fewer words, such as the abstract and technical vocabulary needed during science instruction (Cunningham & Stanovich, 1997). Struggling readers are also less able to comprehend science texts and make science-related inferences compared with individuals who have high literacy skills (Tate et al., 2012). Reading is therefore essential for students to access science curricula and fully participate in classroom science instruction. Indeed, empirical study demonstrates that improved reading is associated with increased science achievement among multilingual and monolingual students in elementary school (Foster et al., 2022; Maerten-Rivera et al., 2010). However, multilingual learners face the challenge of developing as a reader as they learn to speak and understand English (Goldenberg, 2020). Therefore, multilingual students may rely on their reading skills less than monolinguals when solving science problems.

Home Learning Environment

The home learning environment is a social process cocreated between family members and influenced by culture, which influences parents' beliefs and attitudes (González et al., 2001). The home learning environment encompasses the frequency of home learning experiences, which includes both direct (sometimes referred to as formal) and indirect (informal) learning experiences. Direct activities are explicitly intended to develop academic skills such as counting or letter knowledge (LeFevre et al., 2009).

The influence of the home learning environment on children's science achievement has not been examined, but parents' explanations of everyday scientific thinking may enhance children's development of scientific conceptual understanding (Fender & Crowley, 2007). In contrast, the relations between the home learning environment and children's math achievement have been examined. Among British kindergartners (Soto Calvo et al., 2020) and small samples of monolingual and linguistically diverse preschoolers in the United States, home-based direct math activities do not significantly predict children's numeracy performance (Kung et al., 2020; Missall et al., 2015). However, other studies find that home-based direct math activities predict numeracy performance among Canadian and Greek kindergarteners (LeFevre et al., 2009, 2010). For Canadian students in kindergarten through second grade, home-based direct math activities also predict math fluency but not their knowledge of math (LeFevre et al., 2009). Given the inconsistent findings about math activities and limited focus on the home environment of multilinguals in prior research, this study explores how direct, home-based science and math learning activities influence multilinguals' and monolinguals' science achievement.

Classroom Science Content

The education system is connected to the microprocesses of children's learning and cognition through teaching practices. Common kindergarten science topics include life science, earth science, and physical science (Kinzie et al., 2014; National Research Council [NRC], 2013), which includes units on science as a field, tools, force and motion, weather and climate, ecosystems, living things, and life cycles (Mantzicopoulos et al., 2013; NRC, 2013). Children in kindergarten classrooms with more frequent and longer-duration science activities are more engaged with science, but this does not lead to higher science achievement in kindergarten or third grade after controlling for SES (Saçkes et al., 2011). Fewer teachers feel prepared to teach science than math and reading, and far less daily instructional time is devoted to science in each elementary school day (18 minutes) than math (57 minutes) and reading/language arts (89 minutes; Banilower et al., 2018). Further, classrooms with higher proportions of Latine students appear to spend less time on science instruction in favor of language and literacy activities (Early et al., 2010). Thus, teachers' perceptions of their lack of preparedness to teach multilinguals (Daniel & Friedman, 2005) and to teach science may influence the coverage of grade-level science content and, subsequently, multilinguals' science achievement.

The Present Study

Building on prior research (Foster et al., 2022; Maerten-Rivera et al., 2010), this study is the first to examine the prediction of kindergarten science achievement and its growth across elementary school and consider a wide range of factors thought to support science achievement. The guiding research questions for this study are:

1. To what extent do child characteristics (i.e., language proficiency, EF, math and reading achievement), the home learning environment (i.e., parent-engaged science and math activities), and classroom science content coverage predict kindergarten science achievement for multilingual and English monolingual students?
2. To what extent do child characteristics, the home learning environment, and classroom science content coverage predict multilingual and English monolingual students' science achievement growth from kindergarten through fifth grade?

By focusing on how proximal home and school processes affect science achievement and trajectories for multilinguals and monolinguals, we address calls to increase the amount of research focusing on contextual factors with multilinguals (Castro, 2014) and move toward best practices that highlight the need for research to differentiate findings across cultural groups (Cabrera & SRCD Ethnic and Racial Issues Committee, 2013). Understanding the hypothesized relationships among multilinguals and monolinguals could inform classroom instruction and the development of STEM curricula for kindergartners. Kindergarten was chosen because this grade level aligns with the minimum age (i.e., 5–6 years) to which free education, including instruction in science, reading, and math, must be offered in most US states (Diffey & Steffes, 2017). Given that children from low-SES households typically have less access to resources associated with learning traditionally valued by the US education system—that is, English-language books and educational toys (Arnold & Doctoroff, 2003)—and that multilingual children are more likely than English monolinguals to come from lower-SES backgrounds (Foster et al., 2023), SES is included in our analytic models as a control variable. Because SES is not a primary interest in our study, SES is not included in our research questions.

Method

Participants

The data analyzed in this study came from the public-use file of the Early Childhood Longitudinal Study, Kindergarten class of 2010–2011 (ECLS-K:2011; NCES, 2011), a nationally representative cohort of children who entered kindergarten during the 2010–2011 school year.[1] Study participants were students who completed the direct cognitive assessment in English and had data for the primary language spoken in the home ($n = 13{,}358$). Multilingual children ($n = 1{,}022$) were identified by the ECLS-K data set creators as living in a home in which a language other than English[2] was the primary language spoken and who also had parents who reported speaking a non-English language as the primary language in the home during the fall or spring of the student's kindergarten school year (see Table 1 for demographic characteristics).[3]

Table 1. Sample's Demographic Characteristics by Group

	Multilinguals ($n = 1{,}023$)	Monolinguals ($n = 12{,}329$)
Mean age in months (*SD*)	65.64 (4.62)	66.35 (4.57)
Female (*n*, %)	522 (51)	5,975 (48)
Race/Ethnicity:		
White (*n*, %)	44 (4)	7,302 (59)
Black (*n*, %)	33 (3)	1,814 (15)
Hispanic (*n*, %)	632 (62)	1,843 (15)
Asian (*n*, %)	293 (29)	468 (4)
Hawaiian/Pacific Islander (*n*, %)	7 (< 1)	69 (< 1)
American Indian (*n*, %)	3 (< 1)	110 (< 1)
Multiracial (*n*, %)	11 (1)	719 (6)
Child has a disability (*n*, %)	120 (13)	2,172 (21)
Below US Census poverty threshold (*n*, %)	479 (50)	2,082 (20)

Note.—Column percentages reported. Percentages do not equal 100% due to rounding.

The ECLS-K data set includes a few children sampled from each participating school included in the data set. On average, there were 2.6 multilingual students from 395 schools; 206 of those schools (52%) had only one multilingual participant. In contrast, there were 10.8 English monolingual students from 1,139 schools; 206 of those schools (18%) had only one English monolingual participant.

Measures

A thorough description of each measure used in the present study, content coverage, and reliability as reported in the ECLS-K user's manual and psychometric reports can be found in Tourangeau et al. (2015, 2019). We used science achievement data only from the spring of kindergarten through fifth grade because science was not measured in the fall of kindergarten. Measures of children's characteristics such as language proficiency, EF, math achievement, and reading achievement are also from the spring of kindergarten. All achievement, language, and EF data are from the direct assessment of children administered in English. The measures of parent engagement in science and math practices are from the fall of kindergarten, whereas SES is based on fall and spring parent interviews. Measures of science content coverage in the classroom are reported by classroom teachers in the spring of kindergarten.

Language proficiency. Language was measured using the "Simon Says" (receptive) and "Art Show" (expressive) tasks from the Preschool Language Assessment Scale (*pre*LAS; Duncan & De Avila, 2000). The Simon Says task measures receptive language, listening comprehension, the ability to follow directions, and total physical response by having children follow simple directions provided by the examiner in English (e.g., "Point to the floor"). The Art Show task measures expressive language through a picture vocabulary task designed to elicit labels for concrete nouns and single-word responses. Internal consistency of the *pre*LAS total raw number-right scores was .89 for the spring of kindergarten (Tourangeau et al., 2019).

Executive functioning. The Dimensional Change Card Sort (DCCS; Zelazo, 2006) task was administered to assess EF, specifically cognitive flexibility and inhibitory control. In this task, children are instructed to sort a series of 22 bivalent picture cards according to different rules. First, children play the "Color Game" and are instructed to sort the first set of cards based on their color (i.e., red or blue). Second, children play the "Shape Game" and are instructed to sort the cards based on their shapes (i.e., rabbit or boat). Finally, children play the "Border Game" and are instructed to sort the cards based on their color or shape depending on whether the card has a black border around the edges. If the card has a border, the child is to sort by color; if there is no border on the card, the child is to sort by shape. The test-retest reliability intraclass correlation coefficient for the DCCS is .92 (Zelazo et al., 2013).

Math achievement. The math test measured skills in conceptual knowledge, procedural knowledge, and problem-solving. Kindergarten items focused on number sense, relative quantities, and basic operations; basic measurement of objects; identification of basic shapes; basic graphs and probability of coin tosses; and completion of numerical and shape patterns. Internal consistency estimates for the spring kindergarten was 0.93 (Tourangeau et al., 2019).

Reading achievement. The kindergarten reading test measured basic skills, vocabulary, and, to a lesser extent, comprehension. Basic skills include early literacy skills such as phonological awareness, letter recognition, rhyming, and word recognition. To measure vocabulary, children were asked to convey their knowledge both verbally and nonverbally. Reading comprehension skills were assessed by having children identify information specifically stated in text (e.g., definitions, facts, supporting details), make complex inferences within and across texts, and consider the text objectively and judge its appropriateness and quality. Internal consistency estimates for the spring kindergarten was 0.94 (Tourangeau et al., 2015).

Science achievement. The science test measures students' skills and knowledge in scientific inquiry, physical science, life science, and earth and space science. Scientific inquiry items include interpretation of observational data, conducting simple investigations, collecting information using measurement tools, and drawing inferences. Physical science items include understanding ways different things move; the materials that form common objects; basic properties of solids, liquids, and gases; and energy. Life science items include functions of human body parts, functions of animal and plant adaptations, and environmental influences on living organisms. Earth and space science items include the influence of weather on people's daily activities; animal habitats; properties of rocks, soil, and water; and the solar system (Tourangeau et al., 2019). The content in the science test aligns with the four domains in the Next Generation Science Standards, except the standards include an engineering, technology, and applications of science domain (NRC, 2013). Internal consistency estimates for the six waves of science scores range from 0.73 to 0.86 (Tourangeau et al., 2019).

Socioeconomic status. To measure SES, the study used the recommended composite variable as detailed in Tourangeau et al. (2015), which was a continuous composite variable created from parents'/guardians' education level, occupational prestige, and household income (values ranged from −3 to 3; Tourangeau et al., 2019). Reliability statistics were not reported for the composite SES measure, as the reliability of SES scores is not routinely available.

Home environment: Parent-engaged science and math activities. The home environment was measured through parent-engaged science and math activities in a typical week, two variables from the fall of kindergarten (2010) parent interviews. For science activities, parents rated how often they talked about nature, including the weather or watching and discussing nature videos together, or completed science projects together to show their child how the world works (e.g., mixing paint to create different colors, using flashlights to create shadows). For math activities, parents rated how often they or another family member practiced reading, writing, or working with numbers with their child, including time spent on homework, reading a calendar, and practicing in a workbook. The response scale for both variables was 1 = not at all, 2 = once or twice, 3 = 3–6 times, 4 = every day (Tourangeau et al., 2019).

Classroom science methods and content. Kindergarten teachers were given a list of kindergarten-level science topics and asked to indicate whether they would teach each topic by the end of the year (response scale: 0 = No, 1 = Yes). The topics align with the four categories in the direct child science assessment described above. For scientific inquiry, teachers were asked if they teach the scientific method, hands-on activities or investigations in science, laboratory skills or techniques, communicating ideas in science, and relevance of science to society. Teachers responded to 15 items on science content. Physical science topics included water, sound, light, magnetism and electricity, machines and motors, and tools and their uses. Life science topics included the human body, plants and animals, and health, safety, nutrition, and personal hygiene. Finally, earth and space science topics were the solar system and space, weather, and understanding and measuring temperature (Tourangeau et al., 2019). We calculated a sum score for science inquiry using five items, and another sum score for science content by adding up 15 items related to physical, life, and earth and space science.

Data Analytic Overview

Preliminary latent growth curve models and invariance tests. Before addressing our research questions, we completed prerequisite preliminary analyses. The predictors of kindergarten science achievement and its growth were put on the same metric by transforming their raw scores to *z*-scores except for math and reading achievement. Item response theory (IRT)-based theta scores were used for science, math, and reading achievement, which are appropriate for cross-sectional analyses, longitudinal analyses, and for examining differences in overall achievement among subgroups of children (Tourangeau et al., 2015). After considering the correlations, we examined a series of latent growth curve models (LGCMs). The functional form of the latent growth trajectory for science achievement was verified separately for multilinguals and monolinguals, after which their trajectories were modeled separately but simultaneously using multigroup LGCMs. To determine whether differences in initial (i.e., kindergarten) and end (i.e., fifth grade) levels of science achievement and growth were significant, we conducted two series of between-group tests of invariance. The first series was based on unconditional LGCMs. The second series was conditional on the child, home, and classroom variables, which account for SES-related achievement differences. The spring of kindergarten was specified as the intercept in the initial LGCMs; however, fifth grade was specified as the intercept in two tests of invariance (see below). If a model suggested that differences in levels or growth were significant, we conducted a post hoc *t*-test and quantified the magnitude of the difference in the unstandardized growth parameter using Hedges' *g*, which we interpreted according to Cohen's (1988) conventions for small (0.20), medium (0.50), and large (0.80).

Predictors of kindergarten science achievement and science growth from kindergarten to fifth grade. We tested five models to address our research questions and determine how child characteristics, the home learning environment, and classroom science content coverage predict kindergarten science achievement and science achievement growth while accounting for SES. The first four models focus on a specific predictor or set of predictors (i.e., SES, child characteristics, home learning activities, and classroom science content coverage) before estimating the final, fifth model that includes all predictors together. This approach allows us to disentangle the unique from the shared variance in the outcomes accounted for by each model. Within each of the five models, we examined the statistical significance of each predictor separately. Due to the large sample size and the number of tests of significance conducted, the alpha level for tests of statistical significance was set to .01 (for review, see Kim & Choi, 2019).

To avoid biased estimates and loss of statistical power from listwise deletion of cases missing posttest data, we estimated all LGCMs (unconditional and conditional) using full information maximum likelihood estimation with robust standard errors

(MLR) in Mplus (Version 8.4). Using the "Type = Complex" command in conjunction with the "Cluster = Class" command allowed us to correct the standard errors of parameter estimates for nonindependence of students due to nesting within schools. We interpreted estimates of R^2, the variance in the intercept, slope (i.e., linear growth term), and quadratic growth term according to Cohen's (1988) conventions for small ($R^2 = 0.01$–0.08), medium ($R^2 = 0.09$–0.24), and large ($R^2 \geq 0.25$).

Model fit for the unconditional and conditional LGCMs were evaluated using the Bayesian information criteria (BIC), Sample Size Adjusted BIC (SSABIC), root mean square error of approximation (RMSEA), comparative fit index (CFI), standardized root mean square residual (SRMR), and the χ^2 test of model fit. Lower values of the BIC and SSABIC indicate better model fit than higher values. RMSEA and SRMR values $\leq .08$ and CFI $\geq .95$ suggest good fit (Hu & Bentler, 1998). Nested models were compared using the scaled difference χ^2 test statistic (Satorra & Bentler, 2010). Statistically significant results indicate that the model with fewer degrees of freedom is better fitting.

Results

The skew (–7.91) and kurtosis (95.06) for the *pre*Las total score for the monolinguals (see Table 2) exceed Weston and Gore's (2006) recommended interval of |3.00| for skewness and |20.00| for kurtosis. Skewness and kurtosis for all the variables for the multilingual children (|2.00| and |8.03|) and the remaining variables for the English monolingual children (|2.09| and |5.19|) are below Weston and Gore's (2006) recommendations. Given that MLR estimation in Mplus is well known for its ability to reliably estimate models with nonnormal data, we did not transform the *pre*LAS *z*-scores for either group of children. Correlations for all variables are presented in the Table A1.

Preliminary Latent Growth Curve Models

All fit statistics for science achievement support the quadratic model with full fixed and random effects over the linear model for multilinguals (see Table 3, Models 1 and 2) and English monolinguals (see Table 3, Models 3 and 4). The better fit of a quadratic growth model suggests science achievement growth is not steady or constant from kindergarten to fifth grade; rather, there may be periods of acceleration in the growth of the students' science achievement. The fit of the subsequent multigroup LGCM, specifying science achievement as a function of quadratic growth in both groups simultaneously, also fit the data well (see Table 3, Model 5). Thus, all subsequent LGCMs specified science achievement growth as a quadratic function. There is a statistically significant negative correlation between the intercept and slope for monolinguals ($r = -.01$) but not the multilinguals ($r = -.03$), though the magnitude of the correlations is not substantive (Model 5 in Table 3).

Preliminary Tests of Invariance

When Model 5 (quadratic growth no predictors; see Table 3) is used as the baseline, Model 6 (kindergarten intercept equality) fits the data significantly worse than

Table 2. Sample's Descriptive Statistics by Group

	Grade	Multilinguals (n = 1,022)					English Monolinguals (n = 12,329)				
		Missing	*M*	*SD*	Skew	Kurtosis	Missing	*M*	*SD*	Skew	Kurtosis
1. Socioeconomic status	K	26 (3%)	−.54	.81	.63	.02	50 (< 1%)	.06	.77	.24	−.40
2. Parent-engaged science	K	825 (81%)	1.97	.89	.80	.07	1,630 (13%)	2.34	.86	.41	−.44
3. Parent-engaged math	K	825 (81%)	3.44	.76	−1.14	.37	1,623 (13%)	3.55	.62	−1.13	.60
4. Language proficiency	K	0 (0%)	17.85	2.48	−2.00	8.03	0 (0%)	19.59	1.27	−7.91	95.06
5. Executive functioning	K	5 (< 1%)	14.60	3.06	−1.78	3.08	25 (< 1%)	15.34	2.67	−2.09	5.19
6. Math achievement	K	4 (< 1%)	−.50	.61	−.37	.95	28 (< 1%)	−.32	.61	−.59	1.56
7. Reading achievement	K	2 (< 1%)	−.41	.69	−.57	.88	18 (< 1%)	−.21	.61	−.83	2.50
8. Classroom science methods	K	182 (18%)	2.78	1.54	−.13	−1.06	1,049 (9%)	2.72	1.52	−.03	−1.11
9. Classroom science content	K	223 (22%)	8.73	3.43	.07	−.75	1,540 (12%)	8.77	3.42	.01	−.70
10. Science achievement	K	17 (< 1%)	−1.16	.72	.03	−.67	64 (< 1%)	−.44	.67	−.70	.38
11. Science achievement	1	82 (8%)	−.35	.84	−.46	.37	1,725 (14%)	.26	.72	−.83	1.39
12. Science achievement	2	144 (14%)	.47	.81	−.62	.95	2,654 (22%)	.86	.68	−.91	2.42
13. Science achievement	3	193 (19%)	.97	.67	−.56	.18	3,352 (27%)	1.26	.63	−.87	1.26
14. Science achievement	4	223 (22%)	1.32	.70	−1.07	1.83	3,901 (32%)	1.60	.60	−1.15	2.41
15. Science achievement	5	254 (25%)	1.66	.72	−.83	.91	4,396 (36%)	1.94	.64	−1.25	2.20

Table 3. Model Fit for Unconditional and Conditional Latent Growth Curve Models for Science Achievement

						χ^2 Test of Model Fit			Adjusted χ^2 Change		
Model	BIC	SSABIC	RMSEA	CFI	SRMR	Value	*df*	*p*	Value	*df*	*p*
Multilinguals											
1. Linear growth	8,552	8,517	.267	.715	.198	1,180.58	16	< .001	Baseline Model[a]		
2. Quadratic growth	7,406	7,358	.122	.956	.069	193.32	12	< .001	950.91	4	< .001
English monolinguals											
3. Linear growth	69,583	69,548	.186	.910	.126	6,792.61	16	< .001	Baseline Model[a]		
4. Quadratic growth	61,375	61,327	.085	.986	.043	1,090.46	12	< .001	5,307.34	4	< .001
Multigroup analysis											
5. Quadratic growth no predictors kindergarten intercept	68,821	68,726	.092	.979	.046	1,364.64	24	< .001	Baseline Model[a]		
Multigroup analysis—tests of invariance											
6. Quadratic growth no predictors—kindergarten intercept held to equality	69,486	69,394	.106	.971	.121	1,907.66	25	< .001	688.32	1	< .001
7. Quadratic growth no predictors—linear growth term held to equality	69,110	69,017	.098	.975	.057	1,616.85	25	< .001	336.44	1	< .001
8. Quadratic growth no predictors—quadratic growth term held to equality	68,936	68,844	.093	.978	.049	1,474.20	25	< .001	123.50	1	< .001
9. Quadratic growth no predictors—fifth-grade intercept held to equality	68,880	68,788	.092	.978	.052	1,422.00	25	< .001	57.39	1	< .001
Multigroup analysis											
10. Quadratic growth all predictors	325,048	324,441	.053	.975	.021	1,555.73	79	< .001	Baseline Model[a]		
Multigroup analysis—tests of invariance											
11. Quadratic growth all predictors—kindergarten intercept held to equality	325,167	324,563	.057	.971	.028	1,798.42	80	< .001	20.77	1	< .001
12. Quadratic growth all predictors—linear growth term held to equality	325,134	324,531	.056	.972	.028	1,735.13	80	< .001	21.74	1	< .001
13. Quadratic growth all predictors—quadratic growth term held to equality	325,092	324,489	.054	.973	.025	1,659.77	80	< .001	23.39	1	< .001
14. Quadratic growth all predictors—fifth-grade intercept held to equality	325,041	324,437	.053	.975	.023	1,568.20	80	< .001	4.03	1	.04

Note.—BIC = Bayesian information criterion; SSABIC = sample size adjusted BIC; RMSEA = root mean square error of approximation; CFI = comparative fit index; SRMR = standardized root mean square residual.

[a] The chi square change values within each group compare each model to the baseline model in that group. Statistically significant results indicate that the model with fewer degrees of freedom is better fitting.

Model 5, indicating higher levels of kindergarten science achievement for monolinguals than multilinguals (for *t*-test results, see Table 4; $g = 0.57$, medium effect size). Model 7 (linear growth equality) also fits the data significantly worse than Model 5, indicating that multilinguals develop scientific knowledge at a faster rate than monolinguals ($g = 0.53$, medium effect size). Despite their accelerated early growth, multilinguals' rate in learning science slows more quickly than monolinguals' (see Table 3, Model 8 quadratic growth equality; $g = 0.23$, small effect size). Further, multilinguals' fifth-grade science achievement is lower than monolinguals when the intercepts are recentered (see Table 3, Model 9 fifth-grade intercept equality), but the effect size of this difference was small ($g = 0.17$).[4] Similarly, the pattern of results of the invariance tests conditional on the hypothesized predictors (i.e., Model 10 quadratic growth with predictors in Table 3 is the baseline model) are the same as those for the unconditional models with one notable exception.[5] Namely, on average, the science achievement of multilinguals is not statistically different from that of monolinguals in fifth grade when controlling for the predictors (see Table 3, Model 14). The corresponding effect size is small but in favor of the multilinguals ($g = 0.05$). Figure 1 displays each group's growth trajectories.

Predictors of Kindergarten Science Achievement and Science Growth

Socioeconomic status. The model with SES (see Table 5, Model 1) fit the data well; χ^2 (30) = 1,444.73, $p < .001$, CFI = 0.979, RMSEA = 0.084, SRMR = 0.040. SES predicted kindergarten science achievement for multilinguals ($\beta = .39$, $p < .001$) and monolinguals ($\beta = .41$, $p < .001$), accounting for 15 and 17% of the variance in the intercept, respectively; however, SES is not associated with the linear or quadratic growth terms for either group, accounting for less than 1% of the variance in children's science achievement growth. Thus, SES has a large association on kindergarten science achievement but negligible associations on its growth. Children whose families reported higher SES tended to have higher science scores in kindergarten.

Child characteristics. The child characteristics predictors model fit the data well; χ^2 (48) = 1,382.83, $p < .001$, CFI = 0.976, RMSEA = 0.065, SRMR = 0.030. This model (Table 5, Model 2) indicates that each of the four child variables was statistically significant predictors of kindergarten science achievement in multilinguals and monolinguals (βs = .09 to .50, ps < .001). The child characteristics predictors account for a large amount of the variance in kindergarten science achievement for multilinguals (65%) and monolinguals (60%). Higher language proficiency (βs = .42 and .21), EF (βs = .09 and .12), math achievement (βs = .35 and .50), and reading achievement (βs = .16 and .13) correspond to higher science scores in kindergarten for multilinguals and monolinguals (ps < .001).

The child characteristics predictors account for a moderate amount of variance in the linear (18%) and quadratic (12%) growth terms for multilinguals, but only a small amount of the variance in each growth term for monolinguals (6 and 5%, respectively). The statistically significant negative relationship between language proficiency and the linear slope terms ($\beta = -.43$ and $-.23$, multilinguals and monolinguals, respectively, ps < .001), coupled with the positive relationship between language proficiency and the quadratic terms ($\beta = .27$ and .16, multilinguals and monolinguals, respectively, ps < .001), suggests that students who have lower ELP kindergarten scores in both

Table 4. Comparison of the Growth Parameters within the Unconditional and Conditional Latent Growth Curve Models

	Multilinguals' Science Achievement		Monolinguals' Science Achievement						
	M	*SE*	*M*	*SE*	$M_{Difference}$	*t*	*df*	*p*	Hedges' *g*
Unconditional Models:									
Kindergarten intercepts	−1.169	.030**	−.425	.012**	.744	17.51	13,349	< .0001	.57
Linear slopes	.940	.015**	.706	.004**	.234	16.22	13,349	< .0001	.53
Quadratic terms	−.074	.002**	−.049	.001**	.025	7.18	13,349	< .0001	.23
Fifth-grade intercepts	1.670	.031**	1.877	.011**	.207	5.28	13,349	< .0001	.17
Conditional Models:									
Kindergarten intercepts	−.633	.029**	−.278	.007**	.385	12.31	13,349	< .0001	.36
Linear slopes	.941	.018**	.713	.004**	.228	16.53	13,349	< .0001	.54
Quadratic terms	−.079	.003**	−.051	.001**	.028	3.01	13,349	< .0001	.09
Fifth-grade intercepts	2.067	.030**	2.020	.008**	.047	1.612	13,349	.1069	.05

** $p < .001$.

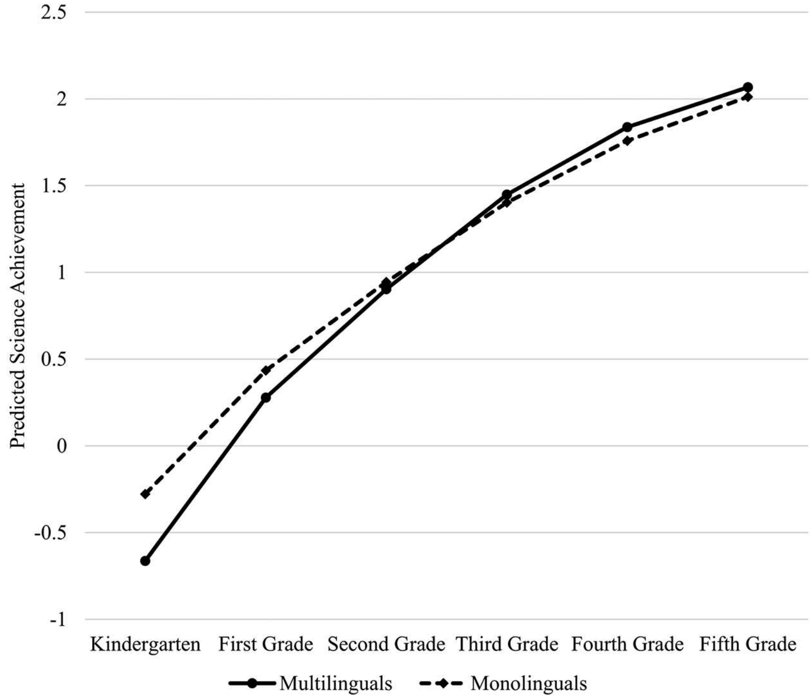

Figure 1. Predicted growth in conditional latent growth curve models. Predicted science achievement are IRT-based theta scores.

groups tend to evidence more science achievement growth during the first half of elementary school compared with the second half. Higher EF scores are not associated with science learning for multilinguals (β = .03 and –.06, *p*s > .01) or monolinguals (β = –.04 and .03, *p*s > .01). However, higher math scores in kindergarten are associated with increased science learning for multilinguals (β = .26, $p < .01$) during the first half of elementary school, whereas multilinguals with lower math scores in kindergarten tend to experience more growth during the second half of elementary school (β = –.26, $p < .01$). Although monolinguals' kindergarten math scores are not associated with science growth during elementary school (β = –.05 and .04, *p*s > .01), higher kindergarten reading scores are associated with increased science learning for monolinguals during the first half of elementary school (β = .20, $p < .01$), whereas monolinguals with lower kindergarten reading scores tend to experience more growth during the second half of elementary school (β = –.26, $p < .01$).

Home learning activities. The home learning activities predictors model fit the data well; χ^2 (36) = 1,482.58, $p < .001$, CFI = 0.976, RMSEA = 0.078, SRMR = 0.036. More frequent parent-engaged science activities predict higher kindergarten science achievement for monolinguals (β = .17, $p < .001$), but not multilinguals (β = .14, $p > .01$; see Table 5, Model 3). Parent-engaged math activities predict kindergarten science achievement for monolinguals (β = –.05, $p < .001$), but not multilinguals (β = .13, $p > .01$), though in different directions. Thus, increased parent-engaged math activities appear to have corresponded to decreased kindergarten science achievement in monolinguals. Together, the parent predictor variables account for

Table 5. Prediction of Science Achievement Growth Parameters for Multilinguals and Monolinguals

		Multilinguals						Monolinguals					
		Intercept		Slope		Quadratic Term		Intercept		Slope		Quadratic Term	
Model	Variable	β (SE)	R^2	β (SE)	R^2	β (SE)	R^2	β (SE)	R^2	β (SE)	R^2	β (SE)	R^2
1.	Socioeconomic status	**.39 (.04)****	.15	–.05 (.05)	.00	.02 (.06)	.00	**.41 (.01)****	.17	.03 (.02)	.00	–.05 (.03)	.00
2.	Child characteristics:		.65		.18		.12		.60		.06		.05
	Language proficiency	**.42 (.03)****		**–.43 (.07)****		**.27 (.08)****		**.21 (.02)****		**–.23 (.04)****		**.16 (.05)****	
	Executive functioning	**.09 (.03)****		.03 (.07)		–.06 (.08)		**.12 (.01)****		–.04 (.03)		.03 (.03)	
	Math achievement	**.35 (.04)****		**.26 (.08)****		**–.26 (.10)***		**.50 (.01)****		–.05 (.04)		.04 (.04)	
	Reading achievement	**.16 (.04)****		.08 (.09)		–.09 (.10)		**.13 (.01)****		**.20 (.04)****		**–.26 (.05)****	
3.	Home learning activities:		.04		.03		.06		.03		.00		.00
	Parent-engaged science activities	.14 (.08)		.16 (.11)		–.24 (.06)		**.17 (.01)****		–.03 (.03)		.00 (.03)	
	Parent-engaged math activities	.13 (.08)		.01 (.12)		–.03 (.06)		**–.05 (.01)****		.02 (.02)		–.03 (.03)	
4.	Classroom:		.01		.01		.03		.00		.00		.00
	Class science methods	.12 (.06)		–.05 (.08)		.09 (.06)		.05 (.02)		.04 (.03)		–.03 (.04)	
	Class science content	–.02 (.06)		–.09 (.09)		.12 (.07)		–.04 (.02)		–.04 (.03)		.07 (.04)	
5.	Final Model:		.67		.20		.19		.63		.06		.06
	Socioeconomic status	**.14 (.03)****		–.05 (.06)		.07 (.07)		**.14 (.01)***		.02 (.03)		.00 (.03)	
	Language proficiency	**.41 (.03)****		**–.43 (.07)****		**.28 (.08)****		**.21 (.02)****		**–.22 (.04)****		**.16 (.05)***	
	Executive functioning	**.09 (.03)***		.05 (.07)		–.08 (.08)		**.12 (.01)****		–.04 (.03)		.03 (.03)	
	Math achievement	**.34 (.04)****		**.27 (.08)***		**–.27 (.10)***		**.45 (.01)****		–.05 (.04)		.04 (.04)	
	Reading achievement	**.12 (.04)***		.08 (.09)		–.09 (.10)		**.12 (.01)****		**.20 (.04)****		**–.26 (.05)****	
	Parent science practices	.07 (.05)		.05 (.11)		–.15 (.12)		**.11 (.01)****		–.02 (.02)		–.00 (.03)	
	Parent math practices	–.00 (.05)		.07 (.10)		–.05 (.14)		**–.05 (.01)***		.02 (.02)		–.02 (.03)	
	Class science content	–.00 (.04)		–.06 (.09)		.10 (.10)		–.01 (.01)		–.03 (.03)		.06 (.04)	
	Class science methods	–.06 (.04)		–.09 (.08)		.13 (.10)		.00 (.01)		.03 (.03)		–.02 (.04)	

Note.—Completely standardized results reported. Bold indicates statistical significance to facilitate interpretation.

* $p < .01$.

** $p < .001$.

4 to 3% of the variance in the intercept in each group, 3 and 6% of the variance in the slope and quadratic growth terms for the multilinguals, and less than 1% of the variance in science achievement growth for the monolinguals.

Classroom science activities. Although the classroom science activities predictor model fit the data well, χ^2 (36) = 1,407.61, $p < .001$, CFI = 0.974, RMSEA = 0.076, SRMR = 0.036, neither classroom-level science variable predicts kindergarten science achievement or growth (see Table 5, Model 4), accounting for ≤ 3% of the variance in kindergarten science achievement and science achievement learning trajectories for both groups.

Final model. The final model fit the data well; χ^2 (79) = 1,555.73, $p < .001$, CFI = 0.975, RMSEA = 0.053, SRMR = 0.023. This model (see Table 5, Model 5) indicates that SES and each of the four child variables are statistically significant predictors of kindergarten science achievement for multilinguals and monolinguals (βs = .09 to .45, ps < .01). Parent-engaged science and math practices are also unique predictors of kindergarten science achievement for the monolinguals (βs = −.05 and .11, ps < .01). Together, the predictors account for 67 and 63% of the variance in kindergarten science achievement for multilinguals and monolinguals, respectively. However, the addition of SES in this model, with all the other predictors, accounts for only a small portion of variance beyond that accounted for by the child characteristics predictor model for multilinguals (2%) and monolinguals (3%).

With respect to the science achievement growth terms in the final model (Table 5, Model 5), the same patterns evident in the SES, child characteristics, and home learning predictor models are observed, controlling for a wider range of variables. Together, the predictors account for 20 and 19% of the variance in the linear and quadratic growth terms for multilinguals, respectively. For monolinguals, the predictors account for 6% of the variance in the linear and quadratic growth terms.

Discussion

The present study seeks to gain a better understanding of factors believed to support the science achievement in kindergarten and its growth through fifth grade for both multilinguals and monolinguals. Guided by the culturally adapted bioecological model of child development (Vélez-Agosto et al., 2017), we examine the utility of child characteristics, the home learning environment, and classroom science content—controlling for SES—in the prediction of science achievement. In doing so, we address calls to increase the amount of research focused on contextual factors in samples of multilinguals and to shift away from assuming that their development and the factors associated with their development are the same as monolinguals (Castro, 2014). As one of the preliminary steps, we examined the functional form of students' science achievement trajectories. The results show that science learning slowed down during the second half of elementary school. In addition, consistent with prior research (Morgan et al., 2016), multilinguals were less knowledgeable of science in kindergarten, likely due to coming from home environments that are culturally different from monolinguals and, therefore, having less knowledge of US science normative concepts. However, as in Morgan et al. (2016), the group of theorized predictors account for a large portion of the variance in kindergarten science achievement

($R^2 = .65$ and .60 for multilinguals and monolinguals, respectively). Accounting for these variables reduces the mean difference in IRT-based theta scores for kindergarten science achievement from 0.74 to 0.39 (see Table 4). Similar to the findings in Morgan et al. (2016), the predictors explain about 50% of the difference in kindergarten science achievement. Because of initial differences in kindergarten, multilinguals have more room to improve, and they attain new science knowledge more rapidly than monolinguals in early elementary school. Unlike Morgan et al. (2016), in the present study, the differences in science achievement were negligible across the groups, though in favor of multilinguals by fifth grade. This finding is promising and may have important implications for elementary education, which will be discussed further.

Science and Child Characteristics

To address our research questions, child characteristics thought to support science achievement were examined. In doing so, the present study extends Foster et al. (2022) and Maerten-Rivera et al. (2010), suggesting that shared yet unique factors influence developmental trajectories for learning science in multilinguals and monolinguals. Given that SES has been identified as a contributing factor to science achievement gaps (e.g., Maerten-Rivera et al., 2010; Morgan et al., 2016), it could be helpful to direct educational resources to lessen the effects of economic disadvantage early in children's lives, which tend to disproportionately affect children from ethnic and linguistic minority backgrounds compared with their White peers (e.g., Shrider et al., 2021).

The associations between ELP, EF, math, and reading achievement with science achievement, all measured in kindergarten, are similar to those observed in other studies (Foster et al., 2022; Maerten-Rivera et al., 2010). However, the present study was able to show a slightly different pattern of predictive relations for science achievement growth. Although language proficiency was associated with positive impacts on kindergarten science achievement, multilinguals and monolinguals with lower ELP tend to experience faster rates of initial growth than their peers with higher language proficiency. This may be due to children with lower levels of language proficiency having lower science scores in kindergarten and, in turn, more science knowledge to learn to catch up to their higher-performing peers. Nevertheless, it is well established that oral language proficiency benefits all children as they acquire academic knowledge. For example, to learn the Next Generation Science Standard crosscutting concept of cause and effect, students must be able to identify independent and dependent variables and to express them using oral language (e.g., "A steeper ramp makes the marble go faster"). In carrying out hypothesis testing, students make predictions about, for example, the change in motion anticipated when two objects touch or collide. The ability to make predictions is a critical oral language skill (LervAag et al., 2018). Students can then carry out their investigation and observe the results to check their predictions. Thus, science terms, concepts, language, and crosscutting processes are interconnected and mutually supporting (Gelman & Brenneman, 2004).

Although EF predicted kindergarten science achievement, EF was not associated with growth in science achievement from kindergarten to fifth grade. In contrast to the hypotheses of others (Anthony & Ogg, 2019; Bauer & Booth, 2019) and our own, EF, as measured by the DCCS, does not appear to facilitate the growth of science-relevant knowledge and skills when accounting for the effects of other child characteristics.

This finding may be related to differences across studies in how EF was measured. Or EF's role in our model may have been diminished due to our inclusion of other child characteristics that had a stronger influence, such as language proficiency and reading and math achievement.

Consistent with previous research (Foster et al., 2022; Hwang, McMaster, & Kendeou, 2022; Maerten-Rivera et al., 2010), this study found that math and reading achievement are related to kindergarten science achievement in multilinguals and monolinguals. However, math achievement corresponds to science learning growth for multilinguals, whereas reading achievement corresponds to science learning growth for monolinguals. Being skilled in math and reading may serve in a compensatory role for multilinguals and monolinguals, respectively, with less knowledge of science (O'Reilly & McNamara, 2007). Indeed, multilinguals and monolinguals with lower kindergarten math and reading scores, respectively, tend to experience more growth in science during the second half of elementary school compared with within-group peers who had higher math and reading scores. Although plausible, recent research shows that the relationship between reading and science is reciprocal throughout the elementary school years (Hwang, Cabell, & Joyner, 2022; Hwang, McMaster, & Kendeou, 2022). Given that the associations between math and science are as strong as those for reading and science (Foster et al., 2022), the relationship between math and science may also be reciprocal. The nonsignificant growth parameters for reading among multilinguals are due, in part, to the smaller sample size and variances of the slope and quadratic terms controlled for by math achievement. We therefore conclude that skilled reading may help all students comprehend science texts and make science-related inferences (Tate et al., 2012) and, therefore, achieve higher science scores. Perhaps being skilled in math compensates for slightly lower levels of English language and literacy proficiency among multilinguals and helps them access the science test items, which require scientific inquiry (e.g., interpreting data and conducting investigations).

Science and the Home Learning Environment

To address our research questions, we examined home learning activities thought to support science achievement. Similar to Fender and Crowley (2007), parent-engaged science activities were associated with individual differences in kindergarten science achievement for the monolinguals, though they did not correspond to increased science growth for either group of children. Perhaps parent-engaged science activities reported in kindergarten do not reach an intensity needed to confer advantages for long-term science achievement growth. For the multilinguals, the lack of statistical significance between parent-engaged science activities and science achievement is likely due in part to a smaller sample size compared with the multilinguals. Indeed, the zero-order correlations between parent-engaged science activities and science achievement were stronger for the multilinguals than the monolinguals.

Despite the associations between math and science achievement, parent-engaged math activities were not substantially associated with science achievement for the multilinguals in our study. In contrast, more frequent parent-engaged math activities correspond to decreased kindergarten science achievement for monolinguals. We advise readers to view these findings cautiously because the magnitude of this association was small and the proportion of missing data for parent-engaged math activities was high relative to the other predictors. Finally, the zero-order correlations between parent-engaged math activities and each measure of science were trivial and nonsignificant for the monolinguals ($r = -.01$ to $-.02$; see Table A1), whereas these correlations were positive and stronger for multilinguals ($r = .09$ to $.23$).

Science and Classroom Science Content

As with child characteristics and home learning activities, we examine the relations between classroom science content coverage and science achievement. Similar to findings from a recent study, kindergarten science content coverage was not associated with science achievement during elementary school (Curran & Kitchin, 2019). This is an important reminder that content (or topic) coverage is not a substitute for instructional quality, instructional quantity, or teachers' science knowledge. In addition, science instruction is important at every grade level, and given the limited science instruction that occurs in US classrooms (see Banilower et al., 2018, for review), long-term positive effects, or benefits of kindergarten science content coverage, arguably, cannot be expected.

Future Directions and Limitations

The present results suggest that science curricula that take advantage of children's oral language, include math and reading targets, and that include family-engaged activities that reinforce science concepts taught in the classroom may increase instructional time dedicated to science content, thereby contributing to increased learning. Moreover, the present results are consistent with emerging research on integrated science instruction (e.g., Cabell & Hwang, 2020; Cervetti & Wright, 2020), which meta-analytic research supports. Namely, the results of Hwang et al. (2022) show the use of integrated instruction corresponds to positive effects for vocabulary, reading comprehension, and content knowledge in science (and social studies). Thus, reading and writing activities can be used to promote content knowledge and science instruction can serve as a lever to foster literacy skills (Hwang, Cabell, & Joyner, 2022; Hwang, McMaster, & Kendeou, 2022).

Despite the breadth of data in the ECLS-K:2011 public-use data set, such datasets are constrained by the variables available in them and how those variables were operationalized. For example, future research can include different measures of ELP to continue disentangling the relationship between language and science achievement. In addition, future studies could directly measure classroom science instruction to better understand factors that support children's learning of science. In the ECLS-K:2011 data set, classroom identification numbers were suppressed, so we accounted for clustering at the school level. In addition, we used the variable recommended by the ECLS-K researchers as our grouping variable, X12LANGST, which was based on parent reports of the languages spoken at home. Although objective measures of language proficiency are preferred over parent report, the results of the present study are consistent with studies that used objective measures (e.g., Hartanto et al., 2018; López & Foster, 2021). Nonetheless, future studies could benefit from using objective measures of language proficiency in multilinguals' home and majority languages.

Empirical studies show that Latine multilinguals are a heterogeneous group. Subgroups of multilinguals exist that can be differentiated by their proficiency in cognitive, linguistic, and academic skills (e.g., López & Foster, 2021). In addition, the multilinguals in this study were diverse, including Latine and Asian families. However, examining the heterogeneity within the group of multilinguals was beyond the scope of this study, the results of which generalize to the broader population of multilinguals in US elementary schools. Future studies could benefit from exploring the heterogeneity in science learning and investigating predictors of science achievement and additional research questions not explored in this study.

Conclusion

The findings from this study strongly challenge the prevailing belief that being multilingual in the United States leads to poor achievement, highlighting the potential for success. To better serve multilingual students, investing in interventions that affirm their cultural and linguistic identities is crucial. The results of this study emphasize leveraging child assets such as bilingualism and parent-engaged science activities to promote equitable learning and fostering inclusive and supporting school environments that value the diversity and unique strengths of multilingual students.

Appendix

Table A1. Correlations Among All Variables for Multilingual (bottom panel) and Monolingual (top panel) Children

	Grade	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Socioeconomic status	K	–	.06**	−.05**	.11**	.17**	.38**	.33**	.03*	−.04	.36**	.37**	.38**	.41**	.39**	.39**
2. Parent-engaged science activities	K	.05	–	.17**	.04**	.02	.06**	.05**	.02	−.01	.13**	.14**	.12**	.13**	.12**	.12**
3. Parent-engaged math activities	K	.14	.10	–	.02	.01	.02	.07**	.00	.01	−.02	−.02	−.01	−.01	−.01	−.01
4. Language proficiency	K	.21**	.04	.21*	–	.25**	.35**	.36**	−.01	−.00	.38**	.36**	.36**	.32**	.31**	.31**
5. Executive functioning	K	.12**	.02	−.07	.25**	–	.37**	.31**	.02	−.01	.33**	.35**	.35**	.33**	.33**	.34**
6. Math achievement	K	.30**	.11	.07	.36**	.35**	–	.76**	.03	−.01	.62**	.64**	.66**	.66**	.63**	.64**
7. Reading achievement	K	.32**	.15	.12	.47**	.31**	.74**	–	.04**	.01	.53**	.57**	.59**	.58**	.55	.56
8. Classroom science methods	K	.08	.07	.09	.02	.04	.06**	.08	–	.54**	.02	.03*	.02	.04**	.04**	.04**
9. Classroom science content	K	.05	.09	−.01	−.00	.02	.01	.03	.60**	–	−.01	−.01	−.02	−.02	.00	.01
10. Science achievement	K	.35**	.13	.09	.54**	.28**	.56**	.54**	.11*	.09	–	.75**	.72**	.71**	.68**	.67**
11. Science achievement	1	.33**	.17	.17	.48**	.35**	.62	.60**	.04	−.01	.71**	–	.82**	.79**	.77**	.76**
12. Science achievement	2	.32**	.20*	.23	.42**	.35**	.65	.60**	.06	−.02	.65**	.80**	–	.84**	.81**	.79**
13. Science achievement	3	.34**	.18	.13	.36**	.32**	.66	.59**	.06	.00	.59**	.75**	.82**	–	.84**	.83**
14. Science achievement	4	.28**	.15	.18	.33**	.30**	.63	.56**	.10	.03	.53**	.71**	.80**	.81**	–	.85**
15. Science achievement	5	.31**	.13	.20	.30**	.34**	.61**	.55	.13	.04	.52**	.68**	.77**	.79**	.84**	–
Multilinguals means (*SD*)		−.71 (1.02)	−.41 (1.03)	−.18 (1.22)	−1.08 (1.67)	−.25 (1.13)	−.50 (.61)	−.41 (.69)	.04 (1.01)	−.02 (1.00)	−1.16 (.72)	−.35 (.84)	.47 (.81)	.97 (.67)	1.32 (.70)	1.66 (.72)
Monolinguals means (*SD*)		.05 (.98)	.01 (.99)	.00 (1.00)	.09 (.86)	.02 (.99)	−.31 (.61)	−.21 (.61)	.00 (1.00)	.00 (1.00)	−.44 (.67)	.26 (.72)	.86 (.68)	1.26 (.63)	1.60 (.60)	1.94 (.64)

Note.—K = kindergarten. Socioeconomic status, Parent-engaged science and math activities, Language, Executive functioning, and Classroom science methods and content were transformed into *z*-scores. The remaining measures reflect IRT-based theta scores.

Table A2. Correlations among Variables in the Final Conditional Model for Multilinguals (bottom panel) and Monolinguals (top panel)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Intercept (kindergarten science achievement)	–	−.02	−.28	.43**	.50**	.42**	.76**	.67**	.17**	−.01	−.01	.02*
2. Slope (linear growth term)	−.05	–	−.87**	.05**	−.31**	−.08**	.04**	.15**	−.04**	.04**	−.03*	.03**
3. Quadratic growth term	−.22**	−.90	–	−.10**	.17**	−.00	−.22**	−.37**	−.02	−.07**	.11**	.02
4. Socioeconomic status	.40**	−.05	.02	–	.11**	.17**	.38**	.33**	.06**	−.05**	−.04**	.03*
5. Language proficiency	.69**	−.39**	.18**	.21**	–	.25**	.35**	.36**	.04**	.02	−.00	−.01
6. Executive functioning	.40**	−.08	−.19**	.12**	.25**	–	.37**	.31**	.02	.01	−.01	.02
7. Math achievement	.70**	.26**	−.40**	.30**	.36**	.35**	–	.76**	.06**	.02	−.01	.03**
8. Reading achievement	.69**	.13**	−.29**	.32**	.47**	.31**	.74**	–	.05**	.07**	.01	.04
9. Parent-engaged science activities	.17	.12	−.28	.05	.04	.02	.11	.15	–	.17**	−.01	.02
10. Parent-engaged math activities	.15	.04	−.06	.14	.21*	−.07	.07	.12	.10	–	.01	.00
11. Classroom science methods	.06	−.16**	.26**	.05	−.00	.02	.01	.03	.09	−.01	–	.54**
12. Classroom science content	.13**	−.15	.25**	.08	.02	.04	.06	.08	.07	.09	.60**	–

* $p < .01$.
** $p < .001$.

Notes

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1. Institutional Review Board approval was not required for the present study because it only involves the study of existing, publicly available data that were prepared with the intent of making the data available for the public.

2. The variable (i.e., X12LANGST) was a composite created to indicate whether English or a non-English language was a primary language spoken in the home. Children of parents who spoke English and another language equally in the home and children of parents who could not choose a primary language were not included ($n = 178$).

3. Primary language of the household fall and spring of kindergarten (i.e., P1PRMLNG and P2PRIMLN).

4. Recentering the science achievement intercepts at fifth grade is statistically equivalent to centering at kindergarten, resulting in equivalent model fit for the unconditional and conditional LGCMs.

5. The variance for parent-engaged math activities was constrained to 1.0 for the group of multilinguals in all conditional models due to a warning message provided by Mplus.

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