Multilingual Learners' Exposure to Science and Language Inputs in Elementary School: *¿Qué sabemos*?

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Abstract
As linguistic diversity continues to increase in the United States public school system, schools are expected to meet the needs of their ever-changing student body. While much attention within education research has understandably focused on multilingual learners' (MLs) English language acquisition, an emergent body of work points to science as an important subject for attention among elementary MLs. We suggest that understanding what *science and language inputs* are afforded to MLs in schools can contribute to understanding the needs and opportunities for enhancing MLs' science learning. This study leveraged nationally representative data from the Early Childhood Longitudinal Study of 2010-11 to explore the science and language inputs available to MLs in elementary school. Using descriptive statistics, our analysis of science and language inputs provides evidence on what MLs have, or do not have, access to inside of their schools. Science inputs appear to be relatively evenly distributed across classrooms serving non-MLs, MLs, and subgroups therein. In comparison, language inputs are differentially distributed across ML subgroups, but they are distributed in ways that may align with student needs. However, while the science inputs do not necessarily vary across subgroups, the language inputs do, and this may affect how students can engage with science inputs. In understanding what science and language inputs MLs are afforded, this study provides a foundation for how to improve formal learning environments for them, especially regarding science learning.

Keywords: English Language Learners, Elementary School, Resources, Science, Opportunity to Learn

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Introduction

As linguistic diversity continues to increase in the United States public school system, schools are expected to meet the needs of their ever-changing student body. As of 2019, students identified as English Language learners (ELLs) made up 10.4 percent of public-school students (National Center for Education Statistics, 2022). Almost twice as many - approximately 21 percent - of school-aged students speak a language other than English at home (Kids Count Data Center, 2021). This group, often termed "multilingual learners" (MLs), is a non-homogenous group, including those receiving formal ELL services at school and those who are using or learning another language alongside English. While much attention within education research has understandably focused on ML students' English language acquisition, an emergent body of work points to science as an important subject for attention among elementary MLs and promoting equity in educational opportunity for this group (Curran & Kellogg 2016; Curran & Kitchin, 2019a).

As STEM (science, technology, engineering, and mathematics) fields continue to grow, there is increased pressure on educators to meet demand for a highly educated STEM workforce (National Science Board, 2018). Within this context, science education has been viewed as increasingly important for learners in K-12 education; however, research findings have demonstrated unequal opportunities across student subgroups. Previous work has found that gaps in science achievement and opportunity exist between different subgroups of students, including language groups (Curran & Kitchin, 2019a; Kieffer et al., 2009; Morgan et al., 2016; Quinn & Cooc, 2015). Many MLs are in the position of acquiring a second language while trying to develop the content and linguistic knowledge that underpin participation in scientific communities, thus making science learning particularly challenging for MLs (Huerta & Jackson, 2010). That said, emergent work has also demonstrated great variation within ML students' science test performance (Curran et al., n.d.), suggesting that there is much to be learned about the variation in school experiences of MLs as it relates to science.

The Next Generation Science Standards (NGSS) emphasize the importance of K-12 students' participation in science and engineering practices (SEPs), or ways of engaging and negotiating meaning within different scientific disciplines (NGSS, 2013a). The NGSS's SEPs include "language intensive" (Hakuta et al, 2013, p. 453) practices, including engaging in arguments from evidence, obtaining, evaluating, and communicating information, and constructing explanations (NGSS, 2013b). While MLs can successfully participate in the SEPs (Foster et al., 2022), they may be especially challenging for MLs given linguistic barriers, potentially contributing to inequitable outcomes.

Education scholars point to educational outcomes as a function of inputs – an education production function – in which the inputs of schooling influence the learning and outcomes of students (Bowles, 1970; Hanushek, 2020). Thus, the cause of these differences in science learning across ML subgroups and their non-ML peers may reflect "opportunity gaps" that arise from differences in opportunity to learn available due to the inputs in their educational environments (Flores, 2007; Hung et al., 2020; Milner, 2012; Welner & Carter, 2013). To date, however, little research has examined in tandem science and language inputs provided to ML students in elementary school science settings.

This study asks what inputs are provided by schools for multilingual learners, specifically for science. We suggest that understanding what *science and language inputs* are afforded to MLs in schools can contribute to understanding the needs and opportunities for enhancing MLs' science learning. The aim of this descriptive paper is to explore the science and language inputs available to MLs in elementary school by examining nationally representative data from the Early Childhood Longitudinal Study of 2011. We address the following research questions:

- How do language inputs vary for multilingual learners compared to non-ML students and within ML subgroups?
- How do science inputs vary for multilingual learners compared to non-ML students and within ML subgroups?

We begin with a review of the literature and our guiding conceptual framework. The paper goes on to discuss our methodological approach in working with this large-scale data set and a presentation of the results with discussion of possible implications for policy and practice.

Conceptual Framework

While definitions of the term "multilingual learner" vary, the term is generally used to refer to students who speak a language other than English at home and may also have limited English proficiency (Harper & de Jong, 2004). The National Science Teacher Association takes a broad view, noting that "multilingual learners are students who are developing proficiency in multiple languages" (NSTA, n.d.). As such, MLs encompass a range of subgroups – from those receiving and not receiving EL services in schools to those speaking common and less common non-English languages and those with varying levels of English spoken in their households (Catalano et al., 2020; Kim et al., 2018). In our empirical analysis, we explore variation across MLs broadly and across several ML subgroups with available indicators in our dataset, responding to recent calls to conceptualize MLs and ELs beyond a binary indicator (Sattin-Bajaj & Mavrogordato, 2019).

In keeping with this broad conceptualization, we use the term ML to collectively refer to students who receive linguistic services in school, as well as those who do not receive formal services yet come from households where a language other than English is regularly spoken. As such, MLs are a linguistically and culturally diverse group of students who experience a variety of educational settings. We include among them students who receive formal English language services at school and have been traditionally labeled as ELL, but also the broader set of students from households where languages other than English are used. That said, we do use *English language learner (ELL) and English learner (EL)* in some cases when referring to prior literature that used the terms or specific variables that used the terms in our data source - the Early Childhood Longitudinal Study, Kindergarten Class of 2011 (ECLS-K:2011).

Conceptually, we posit that the academic success of MLs and subgroups therein in science depends in part on the opportunities afforded them through their schooling environment. The opportunity to learn framework (OTL) points to an examination of the inputs provided by school as facilitating or constraining factors for ML student success in science. In other words, we attempt to place students at the center of our analysis by focusing on the school resources that meet their needs as individual learners (Kaput, 2018).

OTL centers structural and organizational features of schools, teacher pedagogical approaches, and curriculum practices as they relate to the educational experiences of students (Heafner & Plaisance, 2016; Kurz et al., 2012; Stevens 1993a). For example, prior literature has examined OTL for MLs, examining elements including peer interactions, rigor of curriculum, small group instruction, and classroom ELL composition (Estrada et al., 2020). We suggest that when considering ML science learning, it is necessary to conceptualize OTL in terms of both science inputs and language inputs. As noted earlier, the NGSS includes language intensive elements that require the use of language skills to engage with science learning. For example, a science lesson that provided reading materials in a second language or that was coupled with access to a bilingual instructor may shape how ML students engage with the content. Similarly, schools with such resources may prompt science teachers to design lessons that are not constrained by perceived limitations in the ML support available. Such variation in OTL can therefore differentially affect outcomes for MLs and ML subgroups, enhancing or limiting equity in educational outcomes.

Within the framing of OTL, we establish three categories of science and language inputs afforded to multilingual learners. These categories are *instructional, materials,* and *personnel support*. The instructional category includes elements such as instructional time, topics covered, and the formal EL program model. The materials category includes tangible resource inputs, such as science laboratory equipment or non-English reading materials. Finally, the personnel support category includes human capital inputs such as whether a teacher is bilingual, teachers' training in science instruction, and experience teaching MLs. We explore each of these categories of OTL across science and language inputs while recognizing that, in practice, they are intersectional with each other (e.g. the ability to leverage particular instructional inputs may depend on adequate materials or personnel support). As described next, we leverage the OTL framework and these particular categories of inputs to organize the review of literature that follows as well as our operationalization of variables from the ECLS-K.

Background

With this guiding framework, we turn now to a discussion of existing literature on ML students and their opportunities to learn science in the elementary setting. We first provide background on MLs, demonstrating the diversity within the broader group, and then discuss the ML and science inputs they experience.

Multilingual Learners

As stated previously, MLs are a heterogenous group with varied backgrounds and linguistic repertoires. Different terms have been used to capture these varied backgrounds, including *English language learner* and *emergent bilingual*. We use the term *multilingual learner* to encompass students who speak or use a language other than English in their homes, communities, or at school. Over 400 languages are spoken by MLs, though Spanish is spoken by over three-quarters of students receiving formal English language services in schools (National Center for Education Statistics, 2019). Much of the prior research on MLs focuses on students identified as English learners and receiving English language services from a school or district, often using the term ML synonymously with "English language learner". In agreement with the work of scholar Ofelia García (2009), the term of ELL limits these students to being learners or having a limitation when compared to the dominant group of native English speakers. Given the heterogeneity in MLs, we purposefully adopt the broader conceptualization of MLs to include all students who come from households with more than one language spoken. As described earlier, ML success in science classrooms requires both attention to language and content, which we detail below.

Language Inputs

The science learning of MLs may depend in part on the language inputs afforded to them in schools, including the instructional inputs, materials, and characteristics of personnel.

Specifically, types of EL instructional programs, availability of instructional materials in multiple languages, and teacher preparation or linguistic abilities are factors that can vary between ML subgroups across and within schools that are likely to shape ML science learning outcomes.

For ML students, usual instructional resources inside of the school include language programs, different use of native language inside the classroom, and peer to peer interaction. Instructional language programs take on many forms but two to highlight include an English-only model and a dual language model. English-only models develop literacy in the English language only, typically known as English as a second language (ESL) pull-out model and Structured English Immersion (SEI) as well (Moughamian et al., 2009). A dual-language program focuses on developing literacy in two languages simultaneously, also known as a two-way immersion approach (Moughamian et al., 2009). Although both beneficial, MLs who find themselves in a dual-language program environment show positive cognitive processing development as they develop biliteracy (Combs et al., 2005; Bialystok, 2001).

Extensive work has documented the ways that classroom language use can shape ML achievement. On one hand, teacher language use—whether in English or students' home languages—can afford or constrain opportunities for students to engage in meaning-making (Kiramba, 2019). On the other hand, classroom contexts that encourage peer interactions can position students to discuss new academic concepts and develop the language needed for this conceptual development (Pastushenkov et al., 2021). For instance, it is likely that ML students whose home languages are more commonly used in the United States (e.g., Spanish and Chinese) receive home language support in their classrooms and encounter instructional materials in their native language more frequently than those whose home languages are less common and do not have classmates with whom they share a home language.

Prior literature suggests that the ability to maximize the benefits of these multilingual instructional inputs and resources will also vary by the multilingual characteristics of other individuals in the school environment. ML students in classrooms with teachers or paraprofessionals who speak their home language experience growth not only in their home language, but also in English and other academic areas (Goldenberg, 2013). Many educators, however, are not bilingual and, with states varying in requirements for teacher certification (NCELA, n.d.), many ML students are being taught by teachers without a TESOL/ESOL certification and teachers with no prior experience of working with MLs. Besterman and colleagues (2018) found through the analysis of the 2011-12 Schools and Staffing Survey that only 3% of science teachers across the nation held a linguistic certification, despite 58.4% of them reporting English language learners in their classrooms. Having multilingual teachers outside of EL based classrooms allows for MLs to have content such as science adapted to their linguistic learning needs (Besterman et al., 2018; Samson & Collins, 2012).

While less emphasis has been placed on how these services are dispersed across ML student subgroups, literature has found that the variability in these inputs is associated with ML students' academic growth (De Jong, 2013). As a result, access to these inputs shape OTL and the equitable or inequitable learning of MLs and ML subgroups.

Science Inputs

Similar to language inputs, students' opportunity to learn is also influenced by the science inputs available in their school setting. First, instructional inputs including the amount of time spent on science and the content taught may shape students' science learning trajectories. Due to an increased accountability focus on reading and mathematics over the past two decades, time spent on science instruction in elementary schools has lagged behind other subjects and, in some cases, decreased (Blank, 2012; 2013; Griffith & Scharmann, 2008; McMurrer, 2008). Though some earlier studies found the frequency and the duration of science teaching in elementary school did not predict end of year test scores (Saçkes et al., 2011; 2013), a more recent analysis by Curran & Kitchin (2019b) found time on science instruction in elementary school was related to science achievement. Other studies have found that time on science varies considerably across states and schools (Blank, 2013). While the evidence is less persuasive on whether the number of science topics/skills covered are related to greater science achievement (Curran & Kitchin, 2019b; Sackes et al., 2013), it seems clear that instructional time and content coverage are at least necessary though perhaps not sufficient antecedents to science learning. The effects of instructional inputs like time on science and content coverage may be particularly salient for ML students who, depending on program model, may miss out on science instruction if pulled from their classroom to receive additional language instruction (Smith, 2020).

The mixed evidence on time on science and content covered suggests the importance of considering what happens during science instructional time. A body of evidence demonstrates that opportunities for authentic opportunities to engage in science inquiry through investigations and other hands-on experiences are important for learning outcomes (Furtak et al., 2012; Schroeder et al., 2007). Such opportunities may be influenced by the science instructional resources available to students –including laboratory equipment such as beakers and measuring instruments as well as reference resources such as books. It is relatively unknown in the literature whether ML students have less access to science instruction resources at their schools. However, related research has found that ML students are more likely to attend high-poverty schools

(Quintero & Hansen, 2021) that may spend less on instructional resources than low-poverty schools (Duncombe, 2017; Lafortune et al, 2016) and do not have the same access to instructional resources generally (Oakes & Saunders, 2004; Ruby, 2006). ML students are also likely to utilize science materials that are not written in their primary language (such as textbooks).

Finally, science learning is influenced by the qualifications of school personnel, particularly teachers. Some prior research has found that high school teachers with bachelor's degrees or master's degrees in science and mathematics are associated with higher student test scores in those subjects (Coenen et al., 2017; Goldhaber & Brewer, 1996; Harris & Sass, 2011; Rowan et al., 1997; Wayne & Youngs, 2003; Lee 2018; Lee & Mamerow, 2019), though other studies have not found this to be the case (Ladd & Sorensen, 2015). The research is less clear on how teacher's degrees may affect learning and test scores in math and science in the early grades and throughout elementary school (Croninger et al., 2007; Rowan et al., 2002).

In addition to education, prior research has found that teacher experience is important for student's learning in elementary, middle and high school. Some research finds that the benefits of teaching experience are only significant for the first 5 years (Clotfelter et al., 2010; Boyd et al., 2006; Boyd et al. 2008; Nye et al., 2004) while others have found increased experience to be helpful past 5 years (Clotfelter et al., 2006; Clotfelter et al., 2007; Coenen et al., 2017; Paypay & Kraft, 2005). It is clear from prior research that teacher experience is important for student learning across all subjects. And while teacher degree level and subject may be important in high school, less is known about how this impacts elementary level students.

With the literature on these inputs reviewed, prior work has not comprehensively examined the intersection of science and language inputs for the range of MLs. Little has been said on how these inputs vary across ML subgroups, with prior work (Curran et al., n.d.) showcasing the need to examine differences in the experiences of ML subgroups as each experiences their own unique science achievement trajectories. On a national scale, we do not know who has access to what, especially within subgroups of MLs. This study addresses this limitation. We now turn to a discussion of our data and methodology.

Data and Methodology

Our work sought to explore the interaction of ML students' access to science and language inputs within their school. To do so, we used secondary data from the Early Childhood Longitudinal Study, Kindergarten Class of 2011 (ECLS-K:2011). The ECLS-K:2011 is a nationally representative, longitudinal dataset collected by the US Department of Education's National Center for Education Statistics. The ECLS-K:2011 data includes information on a representative set of students who were kindergartners in 2010-11, following them through fifth grade in 2015-16. The ECLS-K:2011 is the most recent, nationally representative dataset for elementary aged students.

Central to our analysis, the ECLS-K:2011 provides a range of variables pertaining to multilingual learners, from the language program they were enrolled in to the resources allocated to families who do not speak the English language, as well as variables pertaining to science learning environments, including science content taught and science tools available. These variables come from a range of assessments, interviews, and questionnaires administered to the children, families, teachers, and schools to build an extensive dataset (Tourangeau et al., 2019).

Our analysis was descriptive in nature, relying on the calculation of means of science and language input variables for the overall sample by grade level as well as comparison of means of these variables across different subgroups (MLs vs. non-MLs as well as subgroups within MLs). The remainder of this section describes our sample, key variables, and data analysis process.

Sample

Given our interest in exploring the prevalence of science and language inputs for MLs as well as ML subgroups, we first created a series of variables representing ML students and ML subgroups. The choice of groups was driven in part by prior literature (Catalano et al., 2020; Kim et al., 2018; Sattin-Bajaj & Mavrogordato, 2019) as well as the availability of measures in the ECLS-K:2011 dataset. Specifically, we examined students for whom a non-English language was spoken in the home (parent report; our definition of ML students) and four subgroups of ML students: 1) whether a non-English language spoken at home was the primary language at home (parent report); 2) whether the teacher perceived a non-English language to be students' native language (teacher report); 3) whether students received formal ELL services at school (teacher report); and 4) whether students' non-English language was Spanish or a less common language (parent report). Each group (MLs and each of the four subgroups) was coded as a binary variable for the purpose of the paper. While not capturing the full diversity within MLs, these variables captured heterogeneity within multilingual learners as well as possible with the data at hand.

Table 1 displays demographic characteristics for MLs as a whole and each of the four subgroups. Students who identified as Hispanic made up sixty percent of the overall ML group. The majority of MLs who spoke a non-Spanish language, in contrast, identified as Asian and had the highest socio-economic status of all groups. MLs experienced teachers with similar characteristics to non-ML students but were in schools that served more racially diverse and lower socio-economic student bodies. For each of these groups, we examined ML and science inputs in three categories: instructional, materials, and personnel support. While these categories overlap and depend on each other in practice, we used this grouping to structure our analysis and discussion. We describe these variables next.

Instructional Inputs

The instructional category included a range of instruction-based variables found in the ECLS-K:2011 dataset. We conceptualized instructional inputs as those related to the act of teaching, concept taught, and the time spent doing so. Variables ranged from specific science content covered in classrooms to the language used for student instruction. For science, these variables consisted of specific content covered inside of classrooms, such as teaching the concepts of light, water, and weather. In the higher-level elementary grades, this category included additional measures such as taking a science test, working on science reports, and specific science skills such as testing hypotheses. A consistent science variable in this category was the amount of time spent on science per week inside the classroom.

For language instructional inputs, we included measures of language of instruction as well as the type of language program the student was part of. The ECLS-K:2011 categorizes ELL programs into two categories: programs that focus on developing students' literacy in two languages and programs that focus on developing students' literacy solely in English (Westat, 2016, pg. 4). Like the science inputs in this section, the amount of time spent on language instruction was also recorded.

Materials Inputs

The materials inputs category included measures of access to various *tangible* items ML students have access to, both related to science and language inputs. For science inputs, the instructional materials category for science included students using science equipment, measuring using tools, and access to science resources at their library. In general, these science inputs included physical materials (equipment) and the interaction with them during instruction. For science inputs, there were fewer variables in this category in earlier grades.

For ML students, language materials inputs included Title III funding, books in different languages, and family resources such as translated communications. Many of the language inputs in this category pertained to Title III funding and the allocation of these funds for different things, including summer learning opportunities and providing family literacy services.

Personnel Inputs

The personnel inputs category included indicators of schools' human capital inputs that directly relate to supporting multilingual learners' science education. We included in this category both school personnel (teachers, administrators, and support staff) as well as students' peers. Science personnel inputs included measures such as the college preparation a teacher had in teaching science and indicators of students collaborating with one another on science projects.

For language inputs, we included measures of personnel and peer students' languages (students and teachers' non-English languages spoken). At the school level, we included measures of personnel making home visits to ML students and schools providing translators during an ML meeting. On the teacher level, the inputs included the language a teacher or aide spoke in class, any certification they held as it pertains to English language instruction, and if there was a full time or part time ESL/Bilingual teacher.

Across the instructional, materials, and personnel inputs, we included all related variables that could be identified in the ECLS-K:2011. In cases where there were questions about whether a variable should be included as a science or language input, multiple members of the research team discussed and came to a consensus. Variables were cleaned in Stata to remove missing data indicators. The full list of science and language inputs are shown in the descriptive tables in the results section.

Data Analysis

We approached our analysis using descriptive statistics and conditional means to answer both of our research questions. Specifically, we calculated means and standard errors of both science and language inputs across MLs and subgroups therein. In particular, we show results for MLs (those who come from households with a non-English language spoken) compared to non-MLs as well as separately for each ML subgroup: a) MLs whose primary home language is English and those whose primary home language is not English, b) MLs who are identified as non-Native English speakers by teachers and those that are not, c) MLs who receive formal ELL services at school and those that do not, and d) MLs who are Spanish speakers and MLs who speak fewer common languages.

Given our interest in documenting differences in inputs across MLs, non-MLs, and subgroups of MLs, we compared means of each science and language input across groups. Across subgroup comparisons, we checked for statistical significance of differences in mean values of each variable across groups using Welch's t-tests at the 0.05 alpha level. To account for missingness in the ECLS-K:2011 dataset, we used multiple imputation. Multiple imputation was conducted in Stata using multivariate normal imputation within grade level using 10 imputed datasets (Plaia & Bondi, 2006; Schafer, 1997).

Appropriate sampling weights were used throughout to account for the sample design of the ECLS as participants in the ECLS-K:2011 were sampled using a clustered and stratified probability design in which geographic regions served as the primary sampling unit (Tourangeau et al., 2015). While our primary analysis used different sampling weights per grade level, allowing us to maximize sample size within grade level rather than across elementary grade levels, we also estimated results using the same standardized sampling weight for each of our grade levels, allowing us to keep a consistent sample size across the years. Results (not shown) were substantively the same.

Limitations

As a descriptive study, our purpose was to understand what science and language inputs MLs in elementary school are experiencing. While not attempting to document how these inputs, or lack thereof, contribute to particular outcomes in schools, this study does provide a foundation for future studies that can examine causal effects of particular inputs. In doing so, however, it is important to recognize several limitations of the work.

First, given the secondary nature of the ECLS-K:2011, we were limited to measures of science and language inputs included on the ECLS surveys. Across grade levels, the inclusion of science and language inputs varied, such as fewer questions on language inputs in the later grades. We recognize there could be other high value inputs students have access to within their classrooms and schools that are not captured in our study. For example, the ECLS did not include information on certain practices like universal design for learning or EL specific professional development for teachers. Furthermore, the ECLS had limited information on how teachers use non-English languages for content area specific instruction. The instructional approaches that teachers employ in integrating second languages within content areas are significant, and we suggest that future iterations of the ECLS or other data sources consider including more detailed and specific information regarding instructional inputs in this regard.

Next, in examining the ECLS-K:2011, we were leveraging the latest nationally representative data on elementary schools. Nevertheless, there are limitations to the timing of the data's collection. In particular, the conclusion of the data collection is now over five years old, and the data collected in the earliest grades over a decade old. We acknowledge that there have been changes both in science standards and teaching practices as well as societal changes, including the Covid-19 pandemic, over this period. While these shifts necessitate future work once newer data are available to examine science and ML inputs in elementary schools, we note that the results of this analysis still hold value for several reasons. First, despite calls during the pandemic to vastly reimagine public education (Bryant et al., 2020), institutional forces have yielded post-pandemic schools that largely resemble those prior to the pandemic, and, arguably may be emphasizing science less as schools seek to make up learning loss in mathematics and reading. Furthermore, the ongoing growth of ML students in public schools and the desire for robust science learning (Lan & de Oliveira, 2019) suggests that the need to focus on elementary school ML students' science learning has not changed. If anything, the pandemic heightened awareness of the needs of student subgroups including multilingual learners (Sugarman & Lazarín, 2020) some of whom experience disrupted education due to immigration (Chang-Bacon, 2021), providing an opportunity to incorporate insights from this analysis more effectively into classrooms.

Finally, we recognize that our measures are subject to measurement error and reporting bias and represent the available inputs at the school or classroom level, not necessarily the inputs experienced directly by individual students. For example, it is important to note that the ECLS had limitations in the availability of indicators of individual students' access to a more extensive range of language inputs, that is specific curriculum and instructional practices ML students experience in the classroom, such as sheltered instruction. In other words, while the ECLS:K-2011 provides a robust picture of available resources and variation across schools and classrooms serving different groups of students, it is limited in information on the variation amongst individual students in the degree to which they experience these particular inputs.

Positionality Statement

Before turning to the results of our analysis, we briefly describe our positionality as it relates to the topic and interpretation of findings. While we approach this work through the conceptual and empirical lens previously described, we also acknowledge that we bring our own prior experiences and predispositions as researchers, educators, and individuals to the analysis. As authors, we represent a diverse group with prior experience as public-school teachers as well as research experience in fields spanning bilingual education to leadership and policy. We include a mix of genders and race/ethnicities as well as individuals who would be classified as multilingual learners as well as those who received formal English language services during school. This diversity provided a wealth of insights into our analysis and shaped collective dialogue around analytic decisions and interpretation of findings.

Overall Findings

We find that MLs have access to various science and language inputs across elementary school. Generally, there were no significant differences amongst the science inputs MLs have access to when compared to non-MLs or across ML subgroups, though we discuss nuances in this finding later. We did, however, find that across ML subgroups there is significant variability when it comes to language inputs. We suggest in our discussion that variability in language inputs may shape equitable ability to engage with science inputs, even when science inputs are available in the classroom.

The sections that follow describe our findings, organized by science and language inputs and our three categories of inputs (instructional, materials, and personnel). For brevity, we focus primarily on kindergarten and fifth grade results, as bookends of the grade levels examined. The findings for first through fourth grade generally aligned with those seen in K and 5th and are available upon request.

Science Inputs

When examining science inputs, we found little reported difference in availability of science inputs between ML students and non-ML students and between the different ML student subgroups. This finding indicates that the science inputs examined in this paper are dispersed relatively equally across classrooms serving more and less linguistically diverse groups.

Instructional

Both ML subgroups and non-ML subgroups were in classrooms that received approximately the same amount of science instructional inputs (see Tables 2 and 3). For example, MLs and non-MLs in kindergarten were in classrooms that spent around two hours per week on lessons or projects on science. In fifth grade, students experienced around three hours of science instruction, both for non-MLs and ML subgroups. Additionally, MLs and non-MLs were exposed to science topics and content (e.g. learning about animals, outer space, the scientific method, etc.) at similar rates. These findings were similar across ML subgroups including those who were receiving ELL services and those who were not, those who spoke Spanish and those who spoke a non-Spanish language, those who spoke a non-English language predominantly in home and those who did not, and those who were both perceived to be native non-English speakers and not. While large or systematic differences in science inputs were not found, we note next how many of the science instructional inputs were underutilized or not as widely available as might be desired, documenting potential shortcomings in science inputs for MLs and non-MLs alike.

While there was little systematic variation across groups in exposure to science instructional inputs, there was variability present amongst the breadth of topics covered inside of elementary classrooms for all students. For science content topics such as plants and animals, weather, and nutrition, over 90% of ML and non-ML kindergarten students were in classrooms where the teacher reported having taught the subject matter. In contrast, only a quarter or so were in classes where machines and motors or dinosaurs and fossils were taught. Less than half were in classrooms where the solar system, light, or sound were taught. In fifth grade, we saw such variation persist as classrooms spent more days a year on topics such as life and earth science (averaging 27 days a year) than working on engineering concepts and spent more time in certain activities (engaging in hands-on activities and discussing science in the news) than on others (preparing a science report). In short, then, there was little variation between MLs and non-MLs and across ML subgroups in access to science instructional inputs, though all these groups had limited exposure to a number of science topics and skills.

Materials

Like our instructional inputs, we found that the use of science materials was similar across ML, non-ML, and ML subgroups (see Tables 2 and 3). For example, we found both MLs and non-MLs in kindergarten were in classrooms where science equipment was used around five times a month. By the time they reached fifth grade, students were less likely than in kindergarten to be in classrooms where the teacher used science equipment, using them around four times a month. In addition to science equipment, we found that ML and non-ML students in kindergarten were in classrooms that spent around the same amount of time working with measurement instruments inside the classroom, which was around two to three times a month, and, in fifth grade, spent similar amounts of time working with virtual science equipment or using books or library resources for science. Any opportunity for students to work hands-on with science concepts, especially when supported with inquiry-based approaches, is beneficial for their conceptual learning (Minner et al., 2010).

Personnel Support

We were limited in our measures for personnel support inputs in science. However, we did find that most of the students in kindergarten, both MLs and non-MLs, were in a classroom with a teacher who had taken a college course in teaching science, totaling around eight out of ten students. In fifth grade, we found that MLs and their subgroups were in classrooms where students spent an average of only 6.4 school days a year working with others on science projects, a potentially missed opportunity for more frequent collective engagement in science learning.

Science Inputs Summary

Figure 1 provides a graphical summary of relative science inputs across MLs, non-MLs, and subgroups. To summarize our findings with regard to science inputs, we found that MLs were in classrooms with similar access to science inputs compared to non-ML students. However, with the global economy becoming increasingly STEM-based (Razi & Zhou, 2022), we suggest it is important that all students across K-5 spend more time on science than our findings indicate is occurring. As we consider further in our discussion section, reading and mathematics are often emphasized in elementary school curriculum over science due to accountability pressures (Judson, 2013; Kingsbury, 2007; McMurrer, 2008; Milner et al., 2012).

Language Inputs Results

We found that MLs had a substantive number of language inputs readily available to them. From ESL certified teachers to paraprofessional support inside the classrooms, MLs nationwide were receiving at least some level of support. Yet, the levels of language inputs were not consistent across all ML subgroups. For example, MLs who spoke Spanish and those receiving formal ELL services tended to have more access to resources than their non-Spanish speaking and non-ELL counterparts. As with science, we turn now to a discussion of these inputs across three conceptual categories: instructional, materials, and personnel support.

Instructional

Unlike science inputs, the language instructional inputs varied greatly across ML subgroups (see Table 4). We found variability across ML subgroups, ranging from access to dual language program models to time spent receiving language instruction. As expected, MLs who were receiving formal ELL services in school experienced more language inputs. This group of MLs was more likely to be enrolled in an English-only program, with an average of 64% while 30% were enrolled in a dual language model. They were more likely to experience a non-English language used for content area instruction, academic support, and conversationally. Additionally, these MLs received specialized language instruction around four days a week in kindergarten. By fifth grade, however, this dropped to an average of one and half days a week spent on instruction in developing literacy in English.

The trend was found in other variables as well, with the amount of language inputs decreasing by the time students were in fifth grade. For example, in fifth grade, most MLs were in classrooms that reported science instruction was not in their native language, though those receiving ELL services, those who were primarily non-English speakers and those speaking Spanish continued to be more likely to receive such bilingual instruction.

Materials

For materials language inputs, we found differences in the distribution across ML subgroups, such that subgroups that arguably have higher needs experienced more of these inputs. Like instructional language inputs, MLs whose primary language was not English, whose native language was a language other than English, and MLs who were identified as receiving ELL services typically had more access to these material language inputs in comparison to the other subgroups. For example, MLs in these three subgroups were more likely to have translated written communication be sent to their families and more likely to be in classrooms where there were books available in Spanish.

Many of the materials language inputs included in the ECLS were supported by Title III funding, which supports students whose primary language is one other than English with educational programs (Florida Department of Education, n.d.). We found that five out of ten kindergarten MLs were in schools receiving Title III funding for language inputs, with the highest percentage of students being those receiving formal ELL services and those for whom a non-English language was native. Similar findings were seen in fifth grade, having six out of ten fifth grade MLs in schools that were receiving Title IIII funding. As with other inputs, MLs who were receiving formal ELL services, those whose non-English language was Spanish, and those who were non-native English speakers or primarily non-English speakers were more likely to be in schools using Title III funding to support MLs. This included use of Title III funding for activities like extended learning time and PD for ELL teachers. Since Title III funding is tied to formal services, other subgroups of ML students were receiving fewer of these services.

Personnel Support

MLs had access to a range of personnel language supports from their teachers, fellow peers, and ESL paraprofessional/aides though not always at the levels that might most benefit their outcomes. In kindergarten, about 35% of ML students were in classrooms where a teacher used a non-English language at least sometimes. This is in alignment with our previous finding of English-only programs being more common than a dual-language program for MLs receiving services. As with other language inputs, students who spoke Spanish tended to be in classrooms where the teacher had more years of experience teaching ESL (1.8 years) than students who spoke a non-Spanish language (less than 1 year). Similar differences were seen when looking at whether or not they were in classrooms where a teacher had an ESL certification, as those receiving services, those who speak Spanish, and have a non-English language as primary were more likely to be in these classrooms in kindergarten.

We found that MLs were more likely to have access to same-language peers than to same language teachers. Over three quarters of ML students were in a classroom with other EL students compared to only 38.1% of non-ML students. Additionally, for MLs who were receiving ELL services, 95.4% found themselves inside a classroom where there was at least one ELL student. MLs then are sorted across schools and classrooms where second language learning is more common (Commins & Miramontes, 2006). When it came to peer collaboration and small group interaction as an instructional strategy, MLs worked in a peer-assisted setting with a non-ELL student 9 times a month. For MLs who were receiving ELL services, this number increased to closer to 10.8 times a month. The literature suggests students can learn communication skills effectively from peers who are at their same level or similarly learning language (Washington-Nortey et al., 2022).

Language Inputs Summary

Looking across the language inputs findings, our results demonstrate variability in access to language inputs within ML students. Figure 2 provides a graphical summary of relative language inputs across MLs, non-MLs, and subgroups. Unlike in science, MLs had different allocations of language inputs across subgroups. As we outlined above, MLs who were receiving services have the most language inputs available. Given that the majority of that student population identified as Hispanic, students who had Spanish as a heritage language tended to also be in classrooms with more available language inputs.

Overall Inputs Findings

Our analysis of science and language inputs provides evidence on what MLs have, or do not have, access to inside of their schools. Science inputs appear to be relatively evenly distributed across classrooms serving non-MLs, MLs, and subgroups therein. All students, however, may be getting too little of certain science inputs. We saw significant variation in the frequency in which science topics were taught, with certain topics receiving little attention in many classrooms.

In comparison, language inputs were differentially distributed across ML subgroups, but they were distributed in ways that may align with student needs, thus enhancing equity. For example, MLs who were receiving ELL services had more access to various language inputs, from materials in another language to paraprofessionals in the classroom. Yet, certain ML subgroups may be receiving too few resources, particularly if not recognized as ELLs formally, yet still be in need of linguistic supports. This may particularly be the case for recently reclassified English language learners, where the reclassification window appears to be found in the upper elementary grade levels (Thompson, 2017) and may result in some students not receiving services that are still needed.

As we consider how the findings around science inputs and language inputs relate, we suggest that, for many MLs, the benefits afforded through science inputs may be conditional on the sort of language inputs students have access to. We note examples where this could both constrain or support science learning. For example, across all MLs, we found that students were in classrooms where a science textbook was read around six times a month but only 36% of them were in classrooms that had books in Spanish. For students who speak a non-English language other than Spanish, the availability of books in their native language is likely significantly less. For many of these ML students then, equitable access to science textbooks as a science input may be limited by inequitable access to books in their native language. In contrast, for MLs receiving ELL services, they worked with fellow peers on science projects around seven times a month and 96% of them were in classrooms with other ELL service receiving students. For these students, then, the prevalence of peers that speak a non-English language may serve as a resource that reinforces the use of group work as a science input.

Discussion

Our study provides some of the most comprehensive evidence on how science and language inputs are experienced by multilingual learners and how these inputs differ between multilingual learners and non-multilingual learners. The results indicate that, nationally, MLs both overall and across the subgroups examined, are in elementary classrooms/schools where availability of the examined science inputs are similar to those of their non-ML peers. Nevertheless, many of these classrooms are, on average, providing relatively low exposure to many of the science inputs examined. In contrast, MLs are in classrooms/schools where substantial language inputs are available, surpassing their non-ML peers in availability of language specific supports. The availability of such language inputs, while fairly ubiquitous for students receiving formal ELL services, varies for other subgroups of MLs. In this section, we summarize and contextualize our findings in extant literature and our theoretical framework while pointing to implications for policy and practice.

Similar Availability of Science Inputs but Room for More Science for All Groups

Across a number of metrics, our results show that ML and non-ML students experience relatively low amounts of certain science inputs. For example, elementary students are experiencing around two hours per week of science instruction, but, comparatively, early elementary students receive three to five times as much instruction in mathematics and reading, respectively (Curran & Kitchin, 2019b). Our findings similarly show that ML and non-ML students experience uneven coverage of science topics, a result consistent with other examinations of the ECLS data (Bassock et al., 2016). While certain topics are covered in most classrooms, others receive very little coverage in particular grades. For example, almost all kindergarten students are in classrooms where plants and animals are taught, yet most are not in classrooms where more complex topics such as light, sound, and simple machines are taught. Prior work has shown that, at least for kindergarten, the frequency of covering science topics may be decreasing as compared to the late 1990s (Bassock et al., 2016).

Even within the time allocated and topics covered, there was evidence of limited opportunities to engage in science using hands on equipment or tools (only 4-5 times per month using equipment across all grade levels). A body of literature points to the importance of engaging in the practice of science through inquiry and hands-on activities, components emphasized in the NGSS as well (Cuevas et al., 2005; Furtak et al., 2012; Minner et al., 2010; Schroeder et al., 2007). NGSS encourages the teaching and integration of a series of science and engineering practices (SEPs) in elementary classrooms. For example, in the early grades, students might conduct an investigation showing how vibrating materials make sound or design an investigation that examines the relative effects of pushes and pulls (NGSS Lead States, 2013a). Yet, our findings suggest this is not occurring regularly for many elementary aged students. Importantly, the effectiveness of particular science inputs may depend on the availability of other inputs. For example, time on science or the teaching of particular topics/practices (instructional inputs) may be differentially effective depending on material and personnel support.

Threats to Equitable Distribution of Science Inputs

While the lack of significant differences in science inputs between ML and non-ML students and across ML subgroups may reflect positive efforts by schools to provide inputs relatively equally (albeit in some cases, in low amounts for all groups), it is important to note that other factors may contribute to how particular ML students experience science inputs. First, since our study relied on teacher and school survey responses, our results could mask variation in who receives particular inputs, even if available at the school or classroom. For example, a teacher may have indicated on the questionnaire that their class has access to particular science inputs; however, individual ML students may be pulled out of class for ELL services during science instruction thus receiving less access to the particular input (Luykx et al., 2008).

Additionally, we note that where schools fall short of providing particular science inputs, such as covering certain topics or providing access to certain science tools, families and communities may differentially provide supplemental, informal access to such resources. For example, access to museums, private tutors, summer camps, and other science enrichment activities are disproportionately available to more advantaged families in ways that may result in differential net access to science inputs across ML and non-ML groups as well as within ML subgroups (Dawson et al., 2019; DeWitt & Archer, 2017; Lee & Buxton, 2010). We point then to the need for future research to further examine the interaction between school and out-of-school science inputs for ML students.

Variation in Opportunities for Leveraging Linguistic Resources in Science Learning

A further consideration in whether ML students can fully access the science inputs available to them is whether their school environment provides the language input supports and opportunities for MLs to leverage their full linguistic repertoire. In contrast to the science inputs, our findings showed wider variation in the availability of language inputs. As expected, we found that ML students receiving formal ELL services at school had access to most language inputs. For example, almost all MLs receiving formal services were in settings where translators were provided for their EL meetings.

However, while the science inputs do not necessarily vary across subgroups, the language inputs do, and this may affect how students can engage with science inputs. The NGSS intersects at multiple points with language including within multiple SEPs (e.g., constructing explanations, asking questions, and communicating information) (NGSS Lead States, 2013b). Language has the power to shape both student comprehension and participation in science. As previously discussed, language inputs are not spread out evenly across ML subgroups. From this, we can infer some MLs are learning in classrooms where they have access to books in their native language while others are not.

In short, multilingual learners' ability to engage with science may vary with the language inputs they have at their disposal within their formal learning settings. With this study as a foundation, future research could explicitly test such relationships and examine how particular inputs relate to student outcomes.

Conclusion

Multilingual learners are a growing part of the diversifying student body in the United States (National Center for Education Statistics, 2022). In understanding what science and language inputs they are afforded, this study provides a foundation for how to improve formal learning environments for them, especially with regard to science learning. This study has demonstrated that, as reported by teachers and measured by variables included in the ECLS-K:2011, MLs are generally experiencing classroom and school contexts that offer equal access across groups to a number of science inputs. Unfortunately, some science inputs are less common in elementary classrooms than others. While some students may be able to compensate for this through access to informal science learning environments, others may not.

Coupled with variation in language inputs that may shape the way ML students can engage with science inputs, this study demonstrates the importance of considering science inputs in tandem with language inputs. Future research could examine outcomes associated with specific inputs or interactions between a subset of inputs as well as the factors that shape whether particular science and language inputs are used in classrooms. As the federal government begins collecting and releases the next iteration of the Early Childhood Longitudinal Study (ECLS-K:2024), there will be a number of comparative research questions that can build on this study as well as additional opportunities to collect data on MLs' experiences with science and language inputs. The ECLS-K:2011 commenced during the introduction of NGSS practices in pre-pandemic classrooms, making it interesting to observe the changes manifesting in the ECLS-K:2024 within a post-pandemic educational landscape. As noted earlier, the ECLS-K:2024 also offers an opportunity to ask questions about the specific intersection of science and language inputs as well as the experiences of individual ML students with these inputs. This study can serve as a foundational source for future research delving into how specific approaches to science instruction, particularly concerning MLs, have changed over time and may provide ideas for ECLS-K:2024 data collection.

Ultimately, the science learning opportunities of ML students and subgroups therein are potentially shaped by the opportunities to learn afforded by both science and language inputs in school. The availability of these inputs then has implications for the equitable production of a diverse STEM-ready workforce and society. By providing evidence on the availability of these inputs at a national scale, the findings in this study provide a steppingstone to further studying and optimizing the science and language inputs experienced by multilingual learners.

Data Availability Statement

Data used in this study come from the National Center for Education Statistics' (NCES) Early Childhood Longitudinal Study, Kindergarten Class of 2010-11 (ECLS-K:2011). This study uses data from the restricted use version of the dataset which can be accessed by researchers through a license with NCES. More information on Restricted Data Licenses can be found here: https://nces.ed.gov/pubsearch/licenses.asp The replication code used to analyze the data for this study will be publicly available through OpenICPSR following publication.

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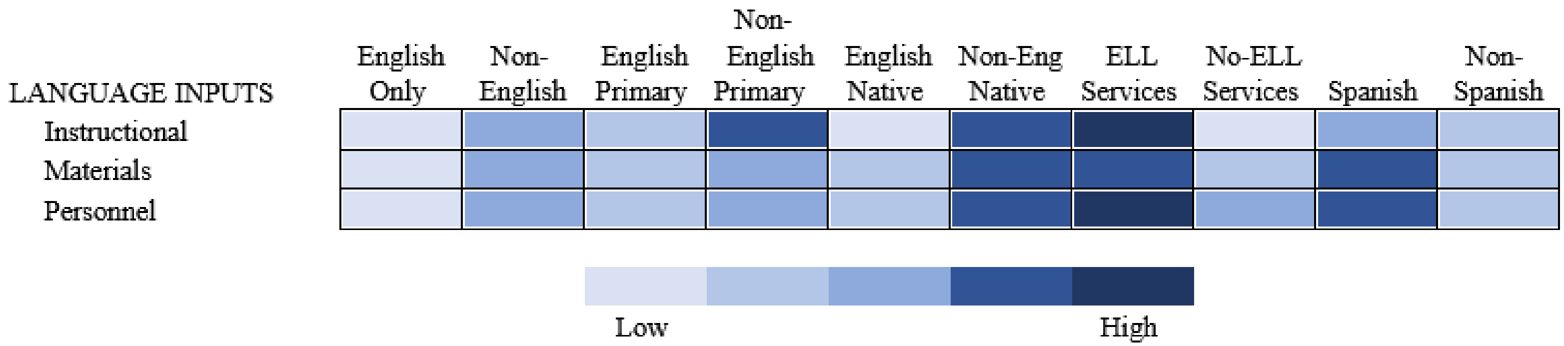
Figure 1. Heat Map of relative distributions of Science Inputs

SCIENCE INPUTS	English Only	Non-English	English Primary	Non-English Primary	English Native	Non-Eng Native	ELL Services	No-ELL Services	Spanish	Non-Spanish
Instructional	Few differences between groups; limited exposure									
Materials	Few differences between groups									
Personnel	Few differences between groups; limited information on personnel support									

Low High

Source: US Department of Education, National Center for Educational Statistics, Early Childhood Longitudinal Study of 2010-11, Previously unpublished tabulation.

Figure 2. Heat Map of relative distributions of Language Inputs



Source: US Department of Education, National Center for Educational Statistics, Early Childhood Longitudinal Study of 2010-11, Previously unpublished tabulation.

Table 1. Means and standard deviations of student, family, teacher, and school characteristics for the K-5 sample

	Full Sample	English Only	Non-English	English Primary	Non-English Primary	English Native	Non-Eng Native	No-ELL Services	ELL Services	Spanish	Non-Spanish
Student Language Characteristics											
Spanish	0.20	0.02	0.60	0.48	0.69	0.49	0.69	0.79	0.49	0.92	<0.01
	(0.40)	(0.13)	(0.49)	(0.50)	(0.46)	(0.50)	(0.46)	(0.41)	(0.50)	(0.27)	(0.06)
Chinese	0.06	<0.01	0.15	0.12	0.17	0.12	0.16	0.17	0.13	0.16	0.13
	(0.23)	(0.07)	(0.36)	(0.32)	(0.38)	(0.32)	(0.37)	(0.37)	(0.34)	(0.36)	(0.34)
Non-English Used at Home in K	0.26	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(0.44)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Non-English Primary at Home in K	0.57	.	0.57	0.00	1.00	0.18	0.81	0.86	0.38	0.59	0.52
	(0.50)	.	(0.50)	(0.00)	(0.00)	(0.38)	(0.39)	(0.35)	(0.48)	(0.49)	(0.50)
ELL Services in K	0.38	.	0.38	0.12	0.59	0.00	0.63	1.00	0.00	0.46	0.24
	(0.49)	.	(0.49)	(0.33)	(0.49)	(0.00)	(0.48)	(0.00)	(0.00)	(0.50)	(0.43)
Spanish Used at Home in K	0.64	.	0.64	0.60	0.67	0.61	0.67	0.77	0.57	1.00	0.00
	(0.48)	.	(0.48)	(0.49)	(0.47)	(0.49)	(0.47)	(0.42)	(0.50)	(0.00)	(0.00)
Teacher Perceives Native Language to be Non-English	0.61	.	0.61	0.26	0.88	0.00	1.00	1.00	0.36	0.63	0.56
	(0.49)	.	(0.49)	(0.44)	(0.33)	(0.00)	(0.00)	(0.00)	(0.48)	(0.48)	(0.50)
Student/Family Characteristics											
Black	0.13	0.16	0.04	0.06	0.03	0.06	0.03	0.02	0.05	0.01	0.09
	(0.34)	(0.37)	(0.20)	(0.24)	(0.16)	(0.24)	(0.17)	(0.15)	(0.23)	(0.11)	(0.29)
White	0.47	0.66	0.10	0.16	0.06	0.17	0.06	0.04	0.15	0.05	0.21
	(0.50)	(0.47)	(0.31)	(0.37)	(0.24)	(0.38)	(0.24)	(0.20)	(0.35)	(0.21)	(0.41)
Hispanic	0.25	0.09	0.60	0.52	0.67	0.53	0.67	0.77	0.51	0.93	0.02
	(0.43)	(0.29)	(0.49)	(0.50)	(0.47)	(0.50)	(0.47)	(0.42)	(0.50)	(0.25)	(0.15)
Asian	0.09	0.02	0.21	0.17	0.23	0.15	0.22	0.15	0.22	<0.01	0.57
	(0.28)	(0.13)	(0.40)	(0.38)	(0.42)	(0.36)	(0.42)	(0.36)	(0.42)	(0.06)	(0.50)
Other Race/Ethnicity	0.06	0.07	0.04	0.08	0.01	0.09	0.02	0.01	0.06	0.01	0.11
	(0.24)	(0.26)	(0.20)	(0.28)	(0.10)	(0.28)	(0.13)	(0.10)	(0.24)	(0.08)	(0.31)
Student male	0.51	0.52	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.51	0.48
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
SES Composite	-0.05	0.09	-0.30	-0.01	-0.51	0.02	-0.50	-0.71	-0.04	-0.62	0.28
	(0.81)	(0.76)	(0.86)	(0.81)	(0.84)	(0.84)	(0.82)	(0.67)	(0.88)	(0.67)	(0.87)

Parent 1 English Proficiency - Not well (0) to very well (3)	2.74	3.00	2.02	2.76	1.45	2.74	1.57	1.33	2.46	1.83	2.36
	(0.69)	(0.00)	(1.04)	(0.51)	(0.99)	(0.56)	(1.03)	(0.99)	(0.82)	(1.12)	(0.79)
School Characteristics											
Public School	0.90	0.88	0.93	0.90	0.95	0.88	0.95	0.99	0.87	0.95	0.87
	(0.30)	(0.33)	(0.26)	(0.30)	(0.22)	(0.33)	(0.22)	(0.09)	(0.33)	(0.21)	(0.33)
City	0.33	0.24	0.49	0.44	0.52	0.41	0.51	0.52	0.44	0.48	0.49
	(0.47)	(0.43)	(0.50)	(0.50)	(0.50)	(0.49)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Suburban	0.38	0.38	0.38	0.41	0.36	0.42	0.37	0.36	0.41	0.38	0.39
	(0.49)	(0.49)	(0.49)	(0.49)	(0.48)	(0.49)	(0.48)	(0.48)	(0.49)	(0.49)	(0.49)
Rural	0.21	0.28	0.10	0.11	0.09	0.12	0.09	0.09	0.11	0.10	0.09
	(0.41)	(0.45)	(0.29)	(0.31)	(0.28)	(0.32)	(0.28)	(0.28)	(0.31)	(0.30)	(0.28)
Town	0.08	0.10	0.03	0.04	0.03	0.05	0.03	0.03	0.04	0.04	0.03
	(0.26)	(0.30)	(0.18)	(0.20)	(0.17)	(0.22)	(0.17)	(0.18)	(0.20)	(0.19)	(0.17)
Black Students (%)	0.13	0.14	0.10	0.10	0.10	0.11	0.10	0.10	0.11	0.09	0.12
	(0.22)	(0.24)	(0.15)	(0.16)	(0.14)	(0.17)	(0.14)	(0.13)	(0.16)	(0.14)	(0.17)
White Students (%)	0.51	0.64	0.30	0.36	0.26	0.37	0.27	0.22	0.37	0.24	0.43
	(0.35)	(0.32)	(0.30)	(0.32)	(0.28)	(0.32)	(0.28)	(0.26)	(0.31)	(0.27)	(0.31)
Asian Students (%)	0.06	0.03	0.08	0.08	0.08	0.07	0.08	0.06	0.09	0.03	0.18
	(0.13)	(0.06)	(0.17)	(0.16)	(0.17)	(0.14)	(0.16)	(0.14)	(0.17)	(0.07)	(0.24)
Hispanic Students (%)	0.23	0.12	0.46	0.39	0.51	0.38	0.50	0.58	0.37	0.59	0.19
	(0.29)	(0.18)	(0.35)	(0.34)	(0.34)	(0.34)	(0.34)	(0.33)	(0.33)	(0.32)	(0.20)
Other Race Students (%)	0.05	0.05	0.04	0.05	0.04	0.05	0.04	0.03	0.05	0.04	0.06
	(0.09)	(0.09)	(0.08)	(0.09)	(0.06)	(0.09)	(0.06)	(0.06)	(0.08)	(0.07)	(0.09)
School FRPL (%)	50.91	43.46	62.73	54.85	68.31	53.40	68.38	75.95	53.49	74.10	41.05
	(31.71)	(29.76)	(32.61)	(33.53)	(30.79)	(33.76)	(30.48)	(25.47)	(33.78)	(27.53)	(30.55)
Prop. of Students in School Who Are ELL	0.15	0.08	0.28	0.21	0.33	0.20	0.33	0.38	0.21	0.34	0.17
	(0.26)	(0.23)	(0.29)	(0.27)	(0.29)	(0.29)	(0.28)	(0.28)	(0.28)	(0.30)	(0.23)
Teacher Characteristics											
Years Teaching	14.56	14.88	13.96	14.43	13.63	14.47	13.69	13.31	14.44	13.28	15.35
	(9.64)	(9.74)	(9.36)	(9.53)	(9.23)	(9.54)	(9.30)	(9.13)	(9.56)	(9.09)	(9.74)
Bachelors	0.50	0.50	0.51	0.52	0.50	0.52	0.51	0.53	0.51	0.54	0.45
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Master's	0.48	0.47	0.47	0.46	0.48	0.46	0.47	0.45	0.47	0.44	0.52

	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Advanced Professional Degree	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
	(0.15)	(0.15)	(0.14)	(0.15)	(0.14)	(0.13)	(0.15)	(0.14)	(0.14)	(0.13)	(0.17)
Regular Certification	0.90	0.92	0.88	0.89	0.88	0.89	0.88	0.88	0.89	0.88	0.89
	(0.30)	(0.28)	(0.32)	(0.32)	(0.33)	(0.31)	(0.33)	(0.33)	(0.32)	(0.33)	(0.32)
Probationary/Temporary Certification	0.10	0.08	0.12	0.11	0.12	0.11	0.12	0.12	0.11	0.12	0.11
	(0.30)	(0.28)	(0.32)	(0.32)	(0.33)	(0.31)	(0.33)	(0.33)	(0.32)	(0.33)	(0.32)
Passed National Board Exam	0.23	0.22	0.26	0.25	0.28	0.26	0.27	0.29	0.25	0.29	0.22
	(0.42)	(0.41)	(0.44)	(0.43)	(0.45)	(0.44)	(0.44)	(0.45)	(0.43)	(0.45)	(0.41)
Highly Qualified Teacher	0.92	0.91	0.94	0.92	0.94	0.91	0.95	0.97	0.91	0.95	0.92
	(0.27)	(0.28)	(0.24)	(0.26)	(0.23)	(0.28)	(0.22)	(0.18)	(0.28)	(0.23)	(0.28)
Observations	109040	59010	21250	9140	11990	7330	11310	7060	11430	13580	7640

Note: Standard deviations in parentheses; Sample sizes span the K-5th grades and vary for individual variables based on missing data patterns. Source: US Department of Education, National Center for Educational Statistics, Early Childhood Longitudinal Study of 2010-11, Previously unpublished tabulation.

Table 2. Kindergarten science inputs by ML subgroups

	Full Sample	English Only	Non-English	English Primary	Non-English Primary	English Native	Non-English Native	ELL Services	No-ELL Services	Spanish	Non-Spanish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Instructional Inputs												
Lessons or projects on science (minutes/week)	119.9	117.1	128.9	125.5	131.7	124.4	132.9	139.1	122.8	136.6	108.0	**e**
	(4.160)	(4.289)	(7.286)	(5.790)	(9.233)	(6.382)	(9.114)	(11.870)	(5.571)	(9.335)	(4.256)	
Taught... (yes/no)												
human body in my class	0.659	0.652	0.680	0.679	0.681	0.679	0.689	0.701	0.665	0.691	0.650	
	(0.019)	(0.021)	(0.023)	(0.027)	(0.027)	(0.029)	(0.025)	(0.032)	(0.025)	(0.027)	(0.028)	
plants and animals in my class	0.956	0.952	0.969	0.973	0.965	0.973	0.966	0.967	0.969	0.968	0.971	
	(0.008)	(0.009)	(0.005)	(0.005)	(0.007)	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.008)	
dinosaurs and fossils in my class	0.317	0.325	0.288	0.307	0.272	0.330	0.260	0.245	0.313	0.282	0.304	
	(0.021)	(0.024)	(0.022)	(0.027)	(0.024)	(0.030)	(0.024)	(0.027)	(0.027)	(0.022)	(0.029)	
solar system and space in my class	0.402	0.409	0.382	0.390	0.374	0.404	0.369	0.349	0.408	0.386	0.369	
	(0.022)	(0.024)	(0.028)	(0.032)	(0.031)	(0.033)	(0.031)	(0.034)	(0.031)	(0.030)	(0.040)	
weather in my class	0.982	0.982	0.984	0.989	0.979	0.988	0.981	0.975	0.989	0.982	0.988	
	(0.004)	(0.005)	(0.006)	(0.003)	(0.008)	(0.004)	(0.008)	(0.012)	(0.004)	(0.007)	(0.004)	
to know and measure temperature in my class	0.685	0.696	0.649	0.672	0.633	0.672	0.635	0.629	0.666	0.644	0.663	
	(0.019)	(0.022)	(0.021)	(0.023)	(0.025)	(0.025)	(0.027)	(0.032)	(0.022)	(0.026)	(0.030)	
water in my class	0.678	0.671	0.700	0.717	0.686	0.702	0.697	0.696	0.704	0.715	0.656	
	(0.018)	(0.020)	(0.020)	(0.025)	(0.023)	(0.026)	(0.022)	(0.029)	(0.021)	(0.025)	(0.032)	
sound in my class	0.425	0.429	0.415	0.422	0.411	0.437	0.404	0.414	0.413	0.432	0.368	
	(0.018)	(0.019)	(0.025)	(0.030)	(0.028)	(0.027)	(0.029)	(0.037)	(0.024)	(0.028)	(0.031)	
light in my class	0.390	0.388	0.398	0.413	0.387	0.426	0.377	0.395	0.402	0.423	0.331	**e**
	(0.019)	(0.021)	(0.027)	(0.030)	(0.029)	(0.029)	(0.030)	(0.038)	(0.026)	(0.028)	(0.033)	
magnetism and electricity in my class	0.410	0.420	0.381	0.419	0.351	0.408	0.364	0.387	0.380	0.391	0.353	
	(0.022)	(0.024)	(0.025)	(0.030)	(0.026)	(0.028)	(0.028)	(0.034)	(0.025)	(0.026)	(0.038)	
machines and motors in my class	0.212	0.205	0.234	0.243	0.228	0.256	0.223	0.244	0.229	0.258	0.172	**e**
	(0.015)	(0.016)	(0.023)	(0.030)	(0.023)	(0.031)	(0.023)	(0.031)	(0.025)	(0.028)	(0.028)	
tools and their uses in my class	0.516	0.504	0.557	0.585	0.534	0.578	0.541	0.553	0.556	0.593	0.461	**e**
	(0.019)	(0.020)	(0.024)	(0.032)	(0.024)	(0.031)	(0.026)	(0.029)	(0.029)	(0.025)	(0.037)	
health safety nutrition and hygiene in my class	0.926	0.929	0.915	0.926	0.904	0.928	0.908	0.910	0.916	0.907	0.933	

	(0.010)	(0.011)	(0.012)	(0.011)	(0.014)	(0.012)	(0.016)	(0.017)	(0.013)	(0.014)	(0.016)	
ecology in my class	0.544	0.542	0.547	0.560	0.537	0.559	0.539	0.540	0.551	0.530	0.596	
	(0.014)	(0.015)	(0.019)	(0.021)	(0.023)	(0.022)	(0.022)	(0.025)	(0.022)	(0.024)	(0.030)	
the scientific method in my class	0.436	0.429	0.460	0.491	0.435	0.483	0.443	0.455	0.461	0.457	0.468	
	(0.017)	(0.019)	(0.023)	(0.027)	(0.026)	(0.028)	(0.025)	(0.029)	(0.024)	(0.027)	(0.037)	
hands-on activities in science in my class	0.907	0.910	0.895	0.911	0.884	0.916	0.882	0.885	0.900	0.892	0.903	
	(0.010)	(0.010)	(0.014)	(0.015)	(0.016)	(0.014)	(0.017)	(0.018)	(0.015)	(0.016)	(0.020)	
lab skills in my class	0.232	0.227	0.246	0.257	0.238	0.245	0.251	0.285	0.224	0.253	0.229	
	(0.014)	(0.016)	(0.018)	(0.021)	(0.027)	(0.022)	(0.027)	(0.036)	(0.018)	(0.023)	(0.031)	
communicating ideas in science in my class	0.641	0.636	0.655	0.680	0.633	0.664	0.653	0.672	0.643	0.662	0.635	
	(0.016)	(0.018)	(0.018)	(0.020)	(0.025)	(0.022)	(0.025)	(0.026)	(0.020)	(0.023)	(0.026)	
the relevance of science to society in my class	0.491	0.484	0.513	0.537	0.495	0.518	0.512	0.530	0.504	0.526	0.483	
	(0.016)	(0.018)	(0.021)	(0.020)	(0.030)	(0.023)	(0.028)	(0.035)	(0.018)	(0.025)	(0.034)	
Taught... (times/month)												
on ordering objects	6.397	6.208	7.004	6.762	7.198	6.749	7.221	7.222	6.852	7.259	6.337	**a,e**
	(0.152)	(0.182)	(0.187)	(0.227)	(0.244)	(0.241)	(0.260)	(0.288)	(0.216)	(0.232)	(0.261)	
on sorting objects into subgroups	7.373	7.149	8.088	7.954	8.203	7.904	8.291	8.283	7.968	8.189	7.845	**a**
	(0.188)	(0.210)	(0.212)	(0.286)	(0.256)	(0.306)	(0.237)	(0.319)	(0.276)	(0.223)	(0.459)	
on identifying relative quantity	11.13	11.10	11.23	11.48	11.04	11.31	11.23	11.37	11.12	11.58	10.35	**e**
	(0.243)	(0.284)	(0.243)	(0.291)	(0.281)	(0.291)	(0.298)	(0.364)	(0.279)	(0.269)	(0.400)	
on reading simple graphs	9.190	9.416	8.467	8.733	8.254	8.771	8.355	8.247	8.615	8.297	8.906	**a**
	(0.252)	(0.290)	(0.261)	(0.281)	(0.348)	(0.318)	(0.360)	(0.413)	(0.298)	(0.297)	(0.412)	
on performing data collection and graphing	7.552	7.703	7.069	7.272	6.929	7.243	7.049	6.959	7.134	6.971	7.361	
	(0.203)	(0.232)	(0.239)	(0.298)	(0.307)	(0.295)	(0.308)	(0.351)	(0.274)	(0.265)	(0.422)	
on using measuring instruments accurately	3.168	3.178	3.135	2.911	3.320	3.031	3.216	3.159	3.067	3.262	2.808	
	(0.148)	(0.166)	(0.186)	(0.212)	(0.242)	(0.236)	(0.242)	(0.262)	(0.203)	(0.226)	(0.234)	
on estimating quantities	4.904	4.874	5.001	5.000	5.034	4.899	5.108	5.014	4.993	5.004	5.008	
	(0.160)	(0.174)	(0.207)	(0.301)	(0.252)	(0.335)	(0.269)	(0.318)	(0.269)	(0.279)	(0.347)	
Using Science to teach Reading (times/month)	3.058	3.052	3.077	3.116	3.045	3.143	3.044	3.072	3.085	3.072	3.093	
	(0.029)	(0.030)	(0.043)	(0.039)	(0.052)	(0.038)	(0.058)	(0.065)	(0.040)	(0.052)	(0.045)	
Materials Inputs												
Used science equipment to teach in kindergarten classroom (times/month)	5.204	5.243	5.079	4.984	5.151	5.110	5.080	5.249	4.973	5.234	4.654	

	(0.205)	(0.225)	(0.286)	(0.276)	(0.358)	(0.275)	(0.382)	(0.506)	(0.258)	(0.344)	(0.263)
Students worked with measuring instruments (times/month)	2.829	2.858	2.734	2.646	2.806	2.815	2.676	2.647	2.778	2.816	2.520
	(0.120)	(0.134)	(0.154)	(0.161)	(0.197)	(0.201)	(0.175)	(0.226)	(0.164)	(0.174)	(0.211)
Personnel Inputs											
Teacher Taken a College Course in Teaching Science (yes/no)	0.825	0.836	0.790	0.790	0.788	0.771	0.802	0.782	0.793	0.782	0.810
	(0.013)	(0.011)	(0.030)	(0.033)	(0.031)	(0.032)	(0.031)	(0.035)	(0.030)	(0.038)	(0.024)
Observations	11990	8950	3040	1340	1680	1190	1730	1120	1850	1950	1090

Note: Standard errors in parentheses; Statistically significant differences on a Welch's t-test between columns indicated by letters in final column: a = 2 to 3, b = 4 to 5, c = 6 to 7, d = 8 to 9, e = 10 to 11; Source: US Department of Education, National Center for Educational Statistics, Early Childhood Longitudinal Study of 2010-11, Previously unpublished tabulation.

Table 3. Fifth grade science inputs by ML subgroups

	Full Sample	English Only	Non-English	English Primary	Non-English Primary	English Native	Non-English Native	ELL Services	No-ELL Services	Spanish	Non-Spanish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Instructional Inputs												
Lessons or projects on science (minutes per week)	172.2	167.5	188.1	181.1	193.7	191.6	199.0	205.6	186.1	192.6	174.4	
	(5.998)	(6.306)	(11.843)	(11.674)	(18.121)	(13.001)	(17.853)	(25.727)	(9.235)	(14.321)	(11.088)	
Taught…(days/year)												
physical science	26.87	26.40	28.45	30.22	27.23	30.51	27.70	26.32	30.09	28.54	28.19	
	(0.981)	(1.015)	(1.647)	(2.493)	(1.673)	(2.309)	(1.746)	(1.996)	(1.946)	(2.023)	(2.438)	
life science	27.19	27.10	27.48	28.33	27.09	27.78	28.03	27.39	28.06	28.05	25.91	
	(1.021)	(1.197)	(1.451)	(2.007)	(1.381)	(2.071)	(1.494)	(1.833)	(1.518)	(1.757)	(2.133)	
earth science	27.29	26.77	29.05	30.15	28.27	29.83	29.63	29.50	29.96	30.16	25.91	
	(1.045)	(1.091)	(1.627)	(2.084)	(1.658)	(2.043)	(1.800)	(2.010)	(1.794)	(1.852)	(2.103)	
conceptual modeling	20.71	20.36	21.87	21.03	22.62	21.82	23.17	24.61	21.24	22.08	21.32	
	(0.877)	(0.948)	(1.598)	(1.712)	(1.990)	(1.454)	(2.212)	(3.041)	(1.171)	(1.986)	(2.162)	
scientific testing	23.91	23.46	25.43	23.38	27.18	24.23	26.98	28.21	24.68	25.38	25.77	
	(0.832)	(0.842)	(1.812)	(1.807)	(2.255)	(1.719)	(2.276)	(3.251)	(1.413)	(2.324)	(2.300)	
analysis and conclusion	23.75	23.28	25.36	23.81	26.75	24.78	26.51	28.47	24.43	25.48	25.23	
	(0.940)	(0.942)	(1.916)	(2.081)	(2.251)	(1.975)	(2.609)	(3.761)	(1.483)	(2.439)	(2.153)	
interdependence of sci/tech/ engineering	12.73	12.31	14.16	11.63	16.08	12.64	15.77	16.92	13.35	14.53	13.14	**b**
	(0.496)	(0.548)	(0.809)	(1.279)	(1.550)	(1.531)	(1.761)	(2.266)	(1.171)	(0.954)	(1.591)	
engineering concepts	12.01	11.65	13.25	10.96	14.94	11.21	14.70	14.46	12.83	13.58	12.24	**b**
	(0.469)	(0.537)	(0.873)	(0.931)	(1.489)	(1.277)	(1.608)	(2.266)	(1.100)	(1.093)	(1.486)	
Students…(times/month)												
generate & test hypotheses	2.964	2.874	3.268	2.882	3.554	3.087	3.533	3.940	2.987	3.384	2.895	
	(0.140)	(0.120)	(0.333)	(0.340)	(0.398)	(0.298)	(0.420)	(0.581)	(0.246)	(0.426)	(0.254)	
prepare a science report	1.347	1.297	1.517	1.504	1.537	1.412	1.631	1.810	1.407	1.545	1.435	
	(0.063)	(0.063)	(0.122)	(0.111)	(0.157)	(0.135)	(0.164)	(0.207)	(0.124)	(0.160)	(0.154)	
discuss science in the news	3.455	3.379	3.716	3.826	3.620	3.851	3.544	3.982	3.506	3.749	3.595	
	(0.146)	(0.157)	(0.303)	(0.407)	(0.338)	(0.468)	(0.363)	(0.485)	(0.348)	(0.370)	(0.413)	
engage in hands-on activities	5.051	5.102	4.876	5.171	4.707	5.140	4.783	4.972	4.921	4.989	4.573	
	(0.260)	(0.274)	(0.467)	(0.734)	(0.362)	(0.603)	(0.425)	(0.526)	(0.501)	(0.588)	(0.459)	
talk about hands-on activities	4.050	3.956	4.368	4.493	4.320	4.541	4.317	4.590	4.287	4.639	3.591	
	(0.228)	(0.202)	(0.505)	(0.721)	(0.400)	(0.589)	(0.461)	(0.598)	(0.497)	(0.630)	(0.344)	
engage in virtual activities	2.281	2.121	2.823	2.618	2.919	2.857	2.837	3.264	2.596	2.964	2.429	**a**
	(0.165)	(0.147)	(0.321)	(0.369)	(0.344)	(0.343)	(0.380)	(0.542)	(0.308)	(0.397)	(0.370)	

talk about virtual activities	1.991	1.859	2.440	2.413	2.485	2.585	2.366	2.715	2.348	2.601	1.983	
	(0.129)	(0.112)	(0.290)	(0.344)	(0.312)	(0.323)	(0.354)	(0.510)	(0.266)	(0.363)	(0.268)	
take science test or quiz	2.550	2.510	2.686	2.715	2.672	2.758	2.643	2.963	2.530	2.867	2.159	
	(0.122)	(0.116)	(0.308)	(0.358)	(0.293)	(0.423)	(0.278)	(0.387)	(0.301)	(0.394)	(0.230)	
Material Inputs												
Students…(times/month)												
use science equipment	4.239	4.183	4.430	4.529	4.315	4.410	4.509	4.874	4.296	4.559	4.075	
	(0.230)	(0.238)	(0.410)	(0.574)	(0.365)	(0.537)	(0.460)	(0.587)	(0.442)	(0.511)	(0.459)	
use virtual science equipment	2.469	2.284	3.097	2.881	3.202	3.097	3.113	3.660	2.855	3.305	2.497	**a**
	(0.180)	(0.162)	(0.353)	(0.388)	(0.397)	(0.346)	(0.432)	(0.611)	(0.346)	(0.412)	(0.533)	
read a science textbook	6.371	6.357	6.419	5.617	6.999	5.820	6.981	7.132	6.273	6.458	6.308	
	(0.293)	(0.308)	(0.513)	(0.514)	(0.627)	(0.517)	(0.677)	(0.811)	(0.518)	(0.581)	(0.944)	
use library resources for science	2.013	1.863	2.523	2.739	2.365	2.637	2.528	2.933	2.410	2.741	1.836	
	(0.165)	(0.131)	(0.433)	(0.518)	(0.400)	(0.610)	(0.449)	(0.625)	(0.465)	(0.544)	(0.224)	
Personnel Inputs												
Students work with others on science projects (times/month)	6.277	6.230	6.437	6.622	6.375	6.627	6.476	7.207	6.251	6.689	5.739	
	(0.335)	(0.327)	(0.608)	(0.739)	(0.578)	(0.807)	(0.650)	(0.805)	(0.660)	(0.735)	(0.570)	
Observations	2990	2280	710	290	410	260	390	260	400	500	220	

Note: Standard errors in parentheses; Statistically significant differences on a Welch's t-test between columns indicated by letters in final column: a = 2 to 3, b = 4 to 5, c = 6 to 7, d = 8 to 9, e = 10 to 11; Source: US Department of Education, National Center for Educational Statistics, Early Childhood Longitudinal Study of 2010-11, Previously unpublished tabulation.

Table 4. Kindergarten language inputs by ML subgroups

	Full Sample	English Only	Non-English	English Primary	Non-English Primary	English Native	Non-English Native	ELL Services	No-ELL Services	Spanish	Non-Spanish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Instructional Inputs												
Received English Program at School (yes/no)	0.0993	0.00860	0.389	0.125	0.599	0	0.667	1	0	0.446	0.237	**a,b,e**
	(0.009)	(0.001)	(0.023)	(0.011)	(0.034)	(.)	(0.034)	(.)	(.)	(0.024)	(0.027)	
Instruction is developing literacy solely in English (yes/no)	0.0640	0.00601	0.249	0.102	0.365	0	0.426	0.639	0	0.261	0.219	**a,b**
	(0.006)	(0.001)	(0.023)	(0.012)	(0.035)	(.)	(0.037)	(0.065)	(.)	(0.029)	(0.025)	
Instruction is developing literacy in two languages (yes/no)	0.0290	0.00205	0.115	0.0164	0.195	0	0.200	0.297	0	0.153	0.0141	**a,b,e**
	(0.008)	(0.001)	(0.028)	(0.005)	(0.047)	(.)	(0.049)	(0.063)	(.)	(0.036)	(0.005)	
Academic instruction in child's native language (0 never – 4 all the time)	0.0903	0.00689	0.357	0.0508	0.603	0	0.613	0.919	0	0.479	0.0307	**a,b,e**
	(0.022)	(0.002)	(0.076)	(0.014)	(0.127)	(.)	(0.132)	(0.171)	(.)	(0.097)	(0.012)	
Days Receiving Specialized language instruction (days/week)	0.431	0.0346	1.697	0.503	2.643	0	2.909	4.365	0	1.988	0.923	**a,b,e**
	(0.044)	(0.006)	(0.114)	(0.052)	(0.170)	(.)	(0.167)	(0.077)	(.)	(0.118)	(0.132)	
Time spent Receiving Specialized language instruction (mins/day)	9.645	0.838	37.79	10.68	59.32	0	64.97	97.25	0	46.08	15.66	**a,b,e**
	(1.224)	(0.142)	(3.838)	(1.251)	(6.100)	(.)	(6.250)	(6.122)	(.)	(4.471)	(2.514)	
Minutes per week spent on specialized Language Instruction (mins/week)	45.48	3.776	178.8	48.09	282.4	0	307.4	460.2	0	220.0	68.63	**a,b,e**
	(5.989)	(0.690)	(18.953)	(6.108)	(30.198)	(.)	(30.802)	(31.267)	(.)	(21.988)	(12.802)	
Non-English used … (0 Never- 4 Almost all the time)												
for academic instruction in Reading/literacy	0.177	0.0806	0.484	0.216	0.700	0.179	0.706	0.946	0.192	0.609	0.150	**a,b,c,d,e**
	(0.025)	(0.012)	(0.076)	(0.032)	(0.116)	(0.032)	(0.116)	(0.155)	(0.031)	(0.097)	(0.030)	
for academic instruction in Mathematics	0.138	0.0613	0.385	0.172	0.557	0.145	0.558	0.746	0.155	0.482	0.126	**a,b,c,d,e**
	(0.019)	(0.010)	(0.057)	(0.029)	(0.085)	(0.029)	(0.084)	(0.115)	(0.029)	(0.072)	(0.030)	
conversationally	0.186	0.0920	0.486	0.242	0.683	0.204	0.697	0.912	0.218	0.601	0.179	**a,b,c,d,e**
	(0.024)	(0.014)	(0.065)	(0.035)	(0.099)	(0.031)	(0.100)	(0.131)	(0.032)	(0.080)	(0.033)	
for Instructional Support	0.180	0.0840	0.487	0.240	0.686	0.197	0.698	0.911	0.219	0.607	0.166	**a,b,c,d,e**

	(0.022)	(0.012)	(0.059)	(0.032)	(0.088)	(0.031)	(0.086)	(0.114)	(0.033)	(0.072)	(0.030)	
for academic instruction in Other Subjects	0.152	0.0682	0.418	0.200	0.595	0.168	0.604	0.800	0.176	0.522	0.142	**a,b,c,d,e**
	(0.022)	(0.010)	(0.065)	(0.034)	(0.096)	(0.031)	(0.099)	(0.129)	(0.030)	(0.082)	(0.031)	
Amount of times ELL students take assessments- Literacy Skills (times/month)	1.620	1.310	2.610	2.252	2.892	1.754	3.229	3.283	2.182	2.861	1.944	**a,b,c,d,e**
	(0.100)	(0.100)	(0.190)	(0.215)	(0.233)	(0.178)	(0.277)	(0.350)	(0.211)	(0.235)	(0.224)	
Amount of times ELL students take assessments- Language AQ (times/month)	1.098	0.851	1.887	1.562	2.139	1.162	2.380	2.730	1.343	2.023	1.531	**a,b,c,d**
	(0.071)	(0.071)	(0.137)	(0.171)	(0.185)	(0.128)	(0.218)	(0.273)	(0.138)	(0.167)	(0.193)	
Material Inputs												
Books in English (yes/no)	0.717	0.743	0.633	0.686	0.590	0.700	0.584	0.539	0.693	0.612	0.690	**a,b,c,d**
	(0.015)	(0.015)	(0.028)	(0.021)	(0.042)	(0.022)	(0.043)	(0.055)	(0.021)	(0.035)	(0.026)	
Books in Spanish (yes/no)	0.279	0.253	0.360	0.298	0.411	0.286	0.415	0.455	0.299	0.393	0.274	**a,b,c,d,e**
	(0.014)	(0.015)	(0.027)	(0.019)	(0.043)	(0.020)	(0.043)	(0.055)	(0.018)	(0.035)	(0.020)	
Title III Funding (yes/no)	0.428	0.384	0.567	0.548	0.583	0.536	0.589	0.649	0.512	0.605	0.469	**a,d,e**
	(0.023)	(0.023)	(0.028)	(0.028)	(0.035)	(0.033)	(0.033)	(0.038)	(0.028)	(0.033)	(0.036)	
Used Title III Funding... (yes/no)												
for pull-out setting for second language instruction	0.302	0.283	0.363	0.343	0.379	0.345	0.373	0.390	0.344	0.361	0.366	**a**
	(0.020)	(0.021)	(0.023)	(0.026)	(0.029)	(0.027)	(0.029)	(0.036)	(0.023)	(0.028)	(0.033)	
for in-class setting for second language instruction	0.270	0.221	0.426	0.396	0.449	0.391	0.453	0.511	0.370	0.459	0.336	**a,d,e**
	(0.022)	(0.021)	(0.032)	(0.034)	(0.035)	(0.038)	(0.034)	(0.039)	(0.031)	(0.039)	(0.032)	
for extended learning times	0.163	0.116	0.311	0.285	0.332	0.271	0.341	0.404	0.249	0.343	0.225	**a,d,e**
	(0.018)	(0.018)	(0.023)	(0.022)	(0.030)	(0.025)	(0.030)	(0.034)	(0.021)	(0.030)	(0.029)	
to improve education schoolwide	0.216	0.173	0.352	0.327	0.371	0.318	0.377	0.447	0.290	0.402	0.219	**a,d,e**
	(0.022)	(0.020)	(0.040)	(0.042)	(0.041)	(0.045)	(0.040)	(0.043)	(0.039)	(0.048)	(0.031)	
for PD for ELL teachers	0.295	0.251	0.435	0.415	0.450	0.414	0.449	0.510	0.385	0.473	0.334	**a,d,e**
	(0.019)	(0.019)	(0.032)	(0.028)	(0.039)	(0.033)	(0.038)	(0.043)	(0.029)	(0.040)	(0.030)	
to provide family literacy services	0.135	0.114	0.201	0.192	0.208	0.183	0.211	0.241	0.173	0.217	0.161	**a**
	(0.015)	(0.016)	(0.023)	(0.024)	(0.026)	(0.024)	(0.026)	(0.031)	(0.023)	(0.029)	(0.025)	
to provide summer learning opportunities	0.132	0.111	0.202	0.213	0.193	0.225	0.190	0.214	0.194	0.214	0.170	**a**
	(0.016)	(0.014)	(0.034)	(0.037)	(0.034)	(0.040)	(0.034)	(0.039)	(0.034)	(0.043)	(0.028)	
to provide support for second language instruction	0.178	0.141	0.296	0.250	0.332	0.253	0.327	0.402	0.225	0.345	0.164	**a,d,e**
	(0.018)	(0.016)	(0.035)	(0.033)	(0.039)	(0.036)	(0.040)	(0.045)	(0.029)	(0.042)	(0.028)	

Meetings for EL families (yes/no)	0.357	0.312	0.499	0.427	0.558	0.389	0.574	0.588	0.439	0.534	0.407	**a,b,c,d,e**
	(0.021)	(0.020)	(0.029)	(0.030)	(0.033)	(0.030)	(0.034)	(0.035)	(0.033)	(0.034)	(0.039)	
Translation of written communications for families (yes/no)	0.697	0.647	0.859	0.807	0.900	0.775	0.912	0.956	0.794	0.911	0.720	**a,b,c,d,e**
	(0.021)	(0.023)	(0.016)	(0.020)	(0.016)	(0.022)	(0.016)	(0.015)	(0.019)	(0.012)	(0.036)	
Personnel Inputs												
EL students in the class (yes/no)	0.469	0.381	0.751	0.597	0.873	0.548	0.896	0.954	0.620	0.779	0.675	**a,b,c,d,e**
	(0.021)	(0.019)	(0.021)	(0.027)	(0.017)	(0.030)	(0.016)	(0.011)	(0.032)	(0.023)	(0.039)	
Students speak…(yes/no)												
Spanish in class	0.500	0.411	0.786	0.675	0.873	0.646	0.887	0.918	0.703	0.853	0.607	**a,b,c,d,e**
	(0.020)	(0.020)	(0.015)	(0.022)	(0.014)	(0.026)	(0.012)	(0.014)	(0.021)	(0.015)	(0.026)	
Vietnamese in class	0.0472	0.0351	0.0858	0.0777	0.0920	0.0769	0.0940	0.0970	0.0779	0.0604	0.154	**a,e**
	(0.006)	(0.005)	(0.013)	(0.016)	(0.014)	(0.016)	(0.014)	(0.019)	(0.012)	(0.010)	(0.031)	
Chinese in class	0.0679	0.0598	0.0935	0.0944	0.0925	0.0893	0.0978	0.0818	0.102	0.0407	0.235	**e**
	(0.009)	(0.007)	(0.019)	(0.024)	(0.017)	(0.022)	(0.019)	(0.020)	(0.019)	(0.008)	(0.050)	
Language other than English in class	0.590	0.506	0.856	0.760	0.932	0.730	0.944	0.950	0.796	0.867	0.828	**a,b,c,d**
	(0.018)	(0.018)	(0.014)	(0.021)	(0.012)	(0.023)	(0.012)	(0.013)	(0.019)	(0.017)	(0.023)	
ELL students working in small groups or individually on Literacy skills (times/month)	5.371	4.223	9.037	7.375	10.38	6.653	10.80	12.36	6.953	9.296	8.365	**a,b,c,d**
	(0.379)	(0.355)	(0.473)	(0.468)	(0.544)	(0.508)	(0.488)	(0.616)	(0.521)	(0.529)	(0.727)	
ELL students working in a peer-assisted setting (times/month)	5.921	4.949	9.027	8.201	9.690	7.488	10.17	10.83	7.917	9.296	8.314	**a,b,c,d**
	(0.320)	(0.318)	(0.333)	(0.406)	(0.372)	(0.439)	(0.361)	(0.488)	(0.455)	(0.347)	(0.626)	
Teacher Uses Non-English Language in Class (yes/no)	0.157	0.0968	0.350	0.229	0.447	0.206	0.454	0.521	0.240	0.409	0.193	**a,b,c,d,e**
	(0.015)	(0.010)	(0.030)	(0.027)	(0.036)	(0.025)	(0.038)	(0.043)	(0.031)	(0.034)	(0.029)	
Teacher/Aide… (yes/no)												
speaks English to ELL students	0.294	0.273	0.361	0.333	0.384	0.312	0.396	0.350	0.368	0.326	0.457	**a,c,e**
	(0.012)	(0.013)	(0.021)	(0.020)	(0.028)	(0.019)	(0.032)	(0.039)	(0.019)	(0.028)	(0.029)	
speaks Spanish to ELL students	0.180	0.114	0.391	0.254	0.499	0.229	0.506	0.615	0.248	0.472	0.173	**a,b,c,d,e**
	(0.015)	(0.012)	(0.024)	(0.019)	(0.032)	(0.022)	(0.036)	(0.037)	(0.024)	(0.029)	(0.019)	
speaks other language to ELL students	0.0133	0.0109	0.0210	0.0226	0.0201	0.0204	0.0227	0.0180	0.0231	0.0134	0.0415	**e**
	(0.004)	(0.003)	(0.006)	(0.008)	(0.006)	(0.008)	(0.007)	(0.007)	(0.007)	(0.004)	(0.013)	
spends 1-15 minutes speaking non-English language	0.100	0.0747	0.183	0.146	0.211	0.130	0.219	0.206	0.165	0.199	0.140	**a,c**
	(0.011)	(0.009)	(0.026)	(0.024)	(0.030)	(0.019)	(0.036)	(0.030)	(0.031)	(0.027)	(0.028)	

ESL certified (yes/no)	0.183	0.112	0.409	0.335	0.468	0.306	0.488	0.599	0.289	0.476	0.230	**a,b,c,d,e**
	(0.018)	(0.015)	(0.024)	(0.027)	(0.027)	(0.025)	(0.027)	(0.032)	(0.023)	(0.024)	(0.037)	
Took ESL course in college (yes/no)	0.359	0.290	0.578	0.514	0.630	0.476	0.653	0.738	0.470	0.625	0.454	**a,b,c,d,e**
	(0.019)	(0.019)	(0.021)	(0.028)	(0.023)	(0.027)	(0.022)	(0.023)	(0.026)	(0.019)	(0.043)	
Years Teacher taught ESL	0.630	0.328	1.595	1.329	1.795	1.025	2.006	2.533	0.986	1.872	0.860	**a,c,d,e**
	(0.078)	(0.062)	(0.159)	(0.179)	(0.186)	(0.177)	(0.228)	(0.261)	(0.138)	(0.181)	(0.218)	
Years Teacher taught Bilingual Education	0.490	0.168	1.521	0.877	2.033	0.793	2.048	2.858	0.659	1.903	0.502	**a,b,c,d,e**
	(0.080)	(0.030)	(0.253)	(0.203)	(0.328)	(0.227)	(0.331)	(0.432)	(0.145)	(0.326)	(0.130)	
Years Teacher taught Dual Language	0.158	0.0662	0.452	0.274	0.593	0.250	0.610	0.856	0.207	0.576	0.122	**a,b,c,d,e**
	(0.032)	(0.019)	(0.094)	(0.071)	(0.132)	(0.071)	(0.126)	(0.166)	(0.053)	(0.122)	(0.041)	
Part Time ESL/Bilingual Teacher (number per school)	0.439	0.473	0.329	0.369	0.300	0.382	0.295	0.278	0.366	0.289	0.436	**a,e**
	(0.031)	(0.034)	(0.031)	(0.037)	(0.033)	(0.038)	(0.035)	(0.040)	(0.034)	(0.033)	(0.044)	
Full Time ESL/Bilingual Teacher (number per school)	1.584	0.920	3.706	2.897	4.356	2.704	4.480	5.547	2.556	4.562	1.425	**a,d,e**
	(0.222)	(0.113)	(0.640)	(0.663)	(0.638)	(0.709)	(0.637)	(0.796)	(0.523)	(0.839)	(0.190)	
Time ESL aide/para works with children (hours/week)	1.153	0.972	1.735	1.190	2.171	0.929	2.358	2.564	1.251	1.952	1.147	
	(0.153)	(0.154)	(0.216)	(0.247)	(0.277)	(0.219)	(0.284)	(0.349)	(0.258)	(0.271)	(0.255)	
Home visits to ELs (yes/no)	0.312	0.285	0.398	0.365	0.425	0.340	0.443	0.470	0.350	0.446	0.268	**a,e**
	(0.024)	(0.025)	(0.041)	(0.044)	(0.042)	(0.047)	(0.041)	(0.051)	(0.038)	(0.052)	(0.035)	
Translators provided in EL meetings (yes/no)	0.745	0.698	0.895	0.855	0.925	0.830	0.937	0.975	0.843	0.922	0.821	**a,b,c,d,e**
	(0.021)	(0.024)	(0.014)	(0.019)	(0.014)	(0.021)	(0.014)	(0.013)	(0.020)	(0.014)	(0.029)	
Observations	11990	8950	3040	1340	1680	1190	1730	1120	1850	1950	1090	

Note: Standard errors in parentheses; Statistically significant differences on a Welch's t-test between columns indicated by letters in final column: a = 2 to 3, b = 4 to 5, c = 6 to 7, d = 8 to 9, e = 10 to 11; Source: US Department of Education, National Center for Educational Statistics, Early Childhood Longitudinal Study of 2010-11, Previously unpublished tabulation.

Table 5. Fifth grade language inputs by ML subgroups

	Full Sample	English Only	Non-English	English Primary	Non-English Primary	English Native	Non-English Native	ELL Services	No-ELL Services	Spanish	Non-Spanish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Instructional Inputs												
Received English Program at School (yes/no)	0.0502	0.00405	0.207	0.0322	0.334	0.0423	0.327	0.435	0.0693	0.262	0.0447	**a,b,c,d,e**
	(0.007)	(0.002)	(0.020)	(0.010)	(0.037)	(0.014)	(0.036)	(0.039)	(0.018)	(0.020)	(0.017)	
Instruction is developing literacy solely in English (yes/no)	0.0329	0.00304	0.134	0.0296	0.208	0.0267	0.204	0.245	0.0598	0.167	0.0377	**a,b,c,d,e**
	(0.004)	(0.002)	(0.017)	(0.010)	(0.025)	(0.011)	(0.024)	(0.036)	(0.018)	(0.024)	(0.016)	
Days Receiving Specialized language instruction: in two languages (days/week)	0.0718	0.00488	0.299	0.0214	0.501	0.0333	0.512	0.783	0.0270	0.396	0.0129	**a,b,c,d,e**
	(0.018)	(0.005)	(0.060)	(0.013)	(0.110)	(0.015)	(0.121)	(0.151)	(0.012)	(0.070)	(0.014)	
Days Receiving Specialized language instruction: in English only (days/week)	0.192	0.0141	0.794	0.136	1.265	0.186	1.282	1.656	0.313	1.018	0.134	**a,b,c,d,e**
	(0.028)	(0.009)	(0.078)	(0.046)	(0.140)	(0.063)	(0.142)	(0.167)	(0.086)	(0.084)	(0.056)	
Days instruction in other programs happens (days/week)	0.0268	0.00196	0.111	0.0418	0.162	0.0185	0.189	0.273	0.0235	0.146	-	**a,c,d,e**
	(0.009)	(0.002)	(0.034)	(0.027)	(0.062)	(0.011)	(0.063)	(0.086)	(0.013)	(0.041)	(-)	
Time spent on instruction in developing literacy in two languages (mins/day)	2.253	0.163	9.341	0.491	16.01	1.244	15.83	23.12	1.622	12.39	0.348	**a,b,c,d,e**
	(0.597)	(0.156)	(2.043)	(0.319)	(3.680)	(0.656)	(3.822)	(5.012)	(0.937)	(2.450)	(0.401)	
Time spent on instruction in developing literacy in English (mins/day)	3.623	0.257	15.04	2.554	24.10	3.897	23.56	32.24	4.976	19.37	2.316	**a,b,c,d,e**
	(0.604)	(0.189)	(1.730)	(1.058)	(3.200)	(1.649)	(3.018)	(3.145)	(1.431)	(1.727)	(1.017)	
Time spent on instruction in other programs (mins/day)	0.473	0.0296	1.977	0.484	3.098	0.484	3.081	4.460	0.483	2.599	0.144	**a,b,c,d,e**
	(0.171)	(0.042)	(0.607)	(0.287)	(1.114)	(0.342)	(0.999)	(1.367)	(0.273)	(0.733)	(0.210)	
Minutes per week spent on two language Instruction (mins/week)	9.162	0.748	37.70	1.921	64.57	4.172	65.32	100.5	3.013	50.00	1.456	**a,b,c,d,e**
	(2.608)	(0.732)	(9.361)	(1.354)	(16.840)	(2.027)	(18.396)	(24.099)	(1.554)	(11.469)	(1.772)	
Minutes per week spent on English only Instruction (mins/week)	15.74	1.147	65.25	11.95	103.6	18.62	104.6	142.0	23.55	84.71	7.990	**a,b,c,d,e**
	(2.645)	(0.838)	(7.745)	(5.227)	(14.077)	(7.875)	(13.576)	(15.015)	(6.781)	(7.817)	(4.414)	

Science instruction in child's native language (0 Never- 4 Almost all the time)	0.0599	0.0259	0.175	0.0629	0.262	0.108	0.249	0.338	0.102	0.186	0.145	**a,b,d**
	(0.012)	(0.009)	(0.039)	(0.027)	(0.067)	(0.039)	(0.071)	(0.097)	(0.030)	(0.049)	(0.053)	
Material Inputs												
Title III Funding (yes/no)	0.465	0.416	0.633	0.589	0.661	0.568	0.672	0.703	0.578	0.648	0.587	**a**
	(0.026)	(0.026)	(0.041)	(0.055)	(0.042)	(0.067)	(0.040)	(0.050)	(0.049)	(0.051)	(0.049)	
Translation of written communications for families (yes/no)	0.685	0.628	0.881	0.833	0.916	0.795	0.925	0.974	0.808	0.916	0.775	**a,b,c,d,e**
	(0.026)	(0.029)	(0.021)	(0.035)	(0.020)	(0.041)	(0.023)	(0.016)	(0.031)	(0.021)	(0.038)	
Personnel Inputs												
EL students in the class (yes/no)	0.375	0.300	0.629	0.537	0.693	0.498	0.713	0.782	0.523	0.692	0.438	**a,b,c,d,e**
	(0.021)	(0.019)	(0.029)	(0.036)	(0.034)	(0.043)	(0.034)	(0.033)	(0.036)	(0.030)	(0.044)	
Years Teacher taught ESL/BIL/DUAL	0.909	0.465	2.414	2.343	2.474	2.468	2.724	3.817	1.812	2.957	0.821	**a,d,e**
	(0.195)	(0.096)	(0.546)	(0.517)	(0.665)	(0.741)	(0.534)	(0.651)	(0.549)	(0.648)	(0.282)	
Part Time ESL/Bilingual Teacher (number per school)	0.484	0.543	0.282	0.254	0.310	0.202	0.375	0.0937	0.438	0.162	0.629	
	(0.068)	(0.043)	(0.219)	(0.244)	(0.220)	(0.276)	(0.219)	(0.246)	(0.233)	(0.265)	(0.150)	
Full Time ESL/Bilingual Teacher (number per school)	1.950	1.019	5.110	4.943	5.216	5.453	4.901	7.102	3.833	6.336	1.490	**a,e**
	(0.481)	(0.159)	(1.555)	(1.735)	(1.483)	(2.045)	(1.299)	(1.675)	(1.481)	(1.909)	(0.440)	
Home visits to ELs (yes/no)	0.321	0.279	0.461	0.419	0.489	0.390	0.481	0.516	0.408	0.525	0.266	**a,e**
	(0.027)	(0.020)	(0.064)	(0.085)	(0.058)	(0.091)	(0.063)	(0.082)	(0.064)	(0.077)	(0.038)	
Translators provided in EL meetings (yes/no)	0.760	0.713	0.921	0.873	0.957	0.861	0.959	0.985	0.878	0.942	0.859	**a,b,c,d,e**
	(0.024)	(0.026)	(0.018)	(0.031)	(0.016)	(0.035)	(0.015)	(0.016)	(0.025)	(0.020)	(0.029)	
Observations	2990	2280	710	290	410	260	390	260	400	500	220	

Note: Standard errors in parentheses; Statistically significant differences on a Welch's t-test between columns indicated by letters in final column: a = 2 to 3, b = 4 to 5, c = 6 to 7, d = 8 to 9, e = 10 to 11; Source: US Department of Education, National Center for Educational Statistics, Early Childhood Longitudinal Study of 2010-11, Previously unpublished tabulation.