MEMORANDUM November 17, 2022

TO: Marisol Castruita
Director, Elementary Curriculum & Development

FROM: Allison E. Matney, Ed.D.
Executive Officer, Research and Accountability

SUBJECT: **THE EFFECTS OF REMOTE LEARNING ON PREKINDERGARTEN PERFORMANCE IN LITERACY AND MATHEMATICS ACHIEVEMENT ONE YEAR AFTER THE COVID-19 PANDEMIC**

The research aimed to examine the association between participation in remote learning and prekindergarten students' academic performance in language arts and literacy and mathematics. A total of 1,156 prekindergarten students who completed one or more assessments in language arts and literacy and mathematics during the 2021–2022 school year and studied in-person or remotely the prior year were included in the study. Data were used from six testing periods between 2020–2021 and 2021–2022 academic years (beginning-of-year, middle-of-year, and end-of-year).

Key findings include:

- The number of prekindergarten students in the district showed an increase of 7 percentage points in 2021–2022 from the previous year (11,747 vs. 10,991).
- The percentage of remote learners who met proficiency at baseline increased by the end of the year on the rapid letter naming subtests (22.0% and 91.0%, respectively), syllabication subtests (8.1% and 82.6%, respectively), and rapid vocabulary subtests (12.5% and 65.8%, respectively).
- Compared to remote learners, there was a lower percentage of in-person learners who met proficiency at baseline, but a higher percentage attained proficiency by end of year on all mathematics subtests.
- A slightly higher rate of in-person learners attained proficiency on the language arts (93.0%) and mathematics (82.4%) subtests compared to remote learners (92% and 79.8%, respectively).
- There was no difference in the odds of scoring proficient on CIRCLE mathematics subtests for remote and in-person learners, except for the rote counting subtests.

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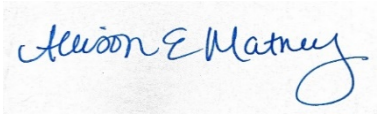

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Attachment

cc: Shawn Bird, Ed.D. Margarita A Gardea

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ANALYZING DATA, MEASURING PERFORMANCE.

EVALUATION REPORT
BUREAU OF PROGRAM EVALUATION

The Effects of Remote Learning on Prekindergarten Performance in Literacy and Mathematics Achievement One Year After the COVID-19 Pandemic

Prepared by Georgia Graham, PhD

Abstract

The research aimed to examine the association between participation in remote learning and prekindergarten students' academic performance in language arts and literacy and mathematics. A total 1,156 prekindergarten students who completed one or more assessments in language arts and literacy and mathematics during the 2021–2022 school year and studied in-person or remotely the prior year were included in the study. Data were used from six testing periods between 2020–2021 and 2021–2022 academic years (beginning-of-year, middle-of-year, end-of-year). Student's academic performance was assessed using three measures of language arts and literacy (rapid letter naming, rapid vocabulary, and syllabication) and four measures of mathematics (shape naming, rote counting, number naming, counting sets). Generalized Estimating Equation analysis was used to assess the relation between learning mode and academic scores, adjusting for potential confounders. A slightly higher rate of in-person learners attained proficiency on the language arts (93.0%) and mathematics (82.4%) subtests compared to remote learners (92% and 79.8%, respectively). There was a statistically significant difference in the likelihood of scoring proficient for remote and in-person learners on the rote counting subtest (OR = 0.69, p <.001, C.I. 0.5–1.0) and the rapid vocabulary subtest (OR = 0.54, p <.001, C.I. 0.4–0.7), with in-person learners showing a higher likelihood of passing compared to remote learners. Language arts and literacy scores were associated with lower proficiency on the rapid letter naming subtests for Black students (OR = 0.36, p <.001, C.I. 0.2–0.6) and Hispanic students (OR = 0.39, p <.001, C.I. 0.2–0.7) compared to their counterparts. Similar associations were observed for mathematics scores for all four subtests for Black and Hispanic students. The trendline showed slight indication of possible 'summer slide' for both in-person and remote leaners across mathematics subtests from the end of the prior year (T2) to beginning of the next school year (T3), except for rote counting. Learning remotely did not seem to be associated with language arts and literacy or mathematics proficiency scores.

Introduction

The shift back and forth between school closures remote/hybrid learning models strained both educators and students, whereas unequal access to and engagement in learning and loss of non-academic services, such as free and reduced-price meals and school-based healthcare, obstructed student opportunities for academic and social emotional learning (Engzell, Frey, & Verhagen, 2021).

Despite not being mandatory, prekindergarten participation has been found to have positive gains when a child enters kindergarten and for long term academic success (Barnett & Jung, 2020). As schools reopened, continued poor supports for early learners can have long-term negative effects (Burns, Skidmore, & Shamir, 2021). Schools have been called upon to address school and home-based trauma, such as gun violence and abuse, as well as to promote human resiliency after hurricanes, earthquakes, floods, and wildfires, and more recently the COVID-19 pandemic (Lambiase & English, 2021). Schools have become the epicenter of support for the wider community, parents, and students. COVID-19 removed the protections afforded students.

Background

In addition to living within the Houston Independent School District (HISD) boundaries,

three and four-year-old children are eligible for free, full-day prekindergarten based on any of the following criteria: (i) unable to speak and understand English; (ii) be economically disadvantaged, which means eligible to participate in the National School Lunch Program; (iii) be a child of a member of the U.S. Armed Forces; (iv) been in state foster care; and (v) homeless (HISD, 2020). HISD also offers tuition-based prekindergarten to early learners who do not meet the eligibility requirements to attend.

Children enroll in one of the four prekindergarten models: (i) early childhood center (ECC); (ii) school-based program (SBP); (iii) Head Start; or (iv) Montessori. HISD offers full-day prekindergarten programs to all eligible students that reside within the district boundaries (HISD, 2018a). During the 2020–2021 academic year, HISD had 142 campuses with prekindergarten that provided nurturing environments for young learners to reach their highest potential. In addition, there were eight ECCs that catered specifically to the youngest learners (3-5 years old). Finally, the district partnered to offer prekindergarten at seven magnet schools and five charter schools. In total, there were 159 HISD campuses that offered the prekindergarten program across three campus types (school-based program, early childhood centers, and charter/magnet schools).

For community-based ECC or a school-based program (SBP) enrollment, home language surveys were administered to the child's parent or guardian. Based on the home language surveys, children were placed in linguistically appropriate HISD prekindergarten programs. Students whose primary language was English were placed in the English program. All instruction in academic subjects and non-academic subjects were delivered in English. If a student was classified as an emergent bilingual, they were assigned to one of the following programs- Transitional Bilingual, English as a Second Language (ESL), or Dual Language (HISD, 2018b). The English as a Second Language (ESL) Program was offered to students with a home language other than English or Spanish. Teachers in an ESL classroom have specific state certification and training to work with students learning English.

In the 2021–2022 school year, the HISD prekindergarten program transitioned to the Savvas Learning Company, formerly Pearson K-12 Learning. In 2020 the Savvas Learning Company launched *Three Cheers for Pre-K*, a ready-to-go prekindergarten curriculum that combines academics and purposeful play for kindergarten readiness (Savvaas Learning Company, 2020). The materials support social-emotional and culturally responsive learning through instruction tied to nine developmentally appropriate themes. Many of the themes connect with kindergarten Texas Essential Knowledge and Skills (TEKS) (TEA, 2020).

Literature Review

With the COVID-19 pandemic and the subsequent school closures, there has been an increased focus on the association between remote learning and learning loss. Research has found that leaning loss can be observed with any interruption in schooling whether due to summer slide, closure due to inclement weather, or more recently the pandemic. The research on learning loss is contentious, with varying findings on whether setback occurs at all and whether inequality widens during school closures, particularly for early learners and middle school students.

Summer slide or melt refers to the loss of skills experienced by students during the time between two school years when they are out of the classroom (Burns, Skidmore, & Shamir, 2021). Whether summer melt or slide exists is debatable. Some research using nationally representative data showed near-zero levels of growth during the summers following kindergarten and 1st grade, which is better described by a phrase like ‘summer slowdown’ (von Hippel, Workman, & Downey, 2018).

Drawing from the literature on summer slide, some studies argue that insight can be gained on potential impacts of this extended pause in classroom instruction when students return to school (Kuhfield & Tarasawa, 2020). However, it has been argued that school closures due to COVID-19 have taken place under very different conditions, making the utility of such a literature debatable (Harmey & Moss, 2021). A more accurate depiction would be to draw on research on learning loss due to extended and unplanned periods of school closure following unprecedented events, such as SARs or weather-related events.

Examining the impact of weather-related closures on student learning, Schwartz and

colleagues (2021) held focus groups and interviewed school practitioners to identify best practices, barriers, and facilitators for distance learning in emergencies. Schools that already offered distance learning prior to an emergency were better equipped to continue instruction during emergency closures. However, a case study of an institution that offered online learning found that face-to-face students were not severely impacted by school closures, while some online students were in the impact zone and in danger of dropping out (Holzweiss, Walker, Chisum, & Sosebee, 2020). Understanding where students reside, therefore, is central to planning for emergency closures.

A few early studies have emerged providing predictions regarding the impact of school closures caused by COVID-19 on student learning. Kuthfield and colleagues (2020), projected that when students returned to school in fall 2020, they would show 63 to 68 percent of learning gains in reading and 37 to 50 percent in math. The negative impacts of school closures were predicted to be greater for students from low-income households (Kuhfield & Tarasawa, 2020) and Black and Hispanic students (Kuhfeld, et al., 2020).

The negative impacts of extended unplanned school closures are especially troubling for early learners who are in the process of developing the foundational skills in math and language arts needed for long term success (Weiland, Unterman, & Shapiro, 2021). Blagg (2021) used Social Genome Model (SGM) to assess how academic learning loss at four different life stages-prekindergarten (age 5), elementary school (grade 3 or age 8), middle childhood (grade 5 or age 11), and early adolescence (grade 9 or age 14)-may affect children's future degree attainment and incomes. For prekindergartners, it was found that intensive elementary school interventions (for example, tutoring) could potentially remediate the effects of a three-month learning loss among early learners.

Research Questions

Participation in prekindergarten is not compulsory. As a result, the rate of participation in prekindergarten reduced during COVID-19. In the Houston Independent School District (HISD), the 2020–2021 school year saw a decrease of 28.4 percentage points in the number of prekindergarten students in the district (Graham, 2021). Of those enrolled in the prekindergarten program, 50.1 percent were learning in person, 28.7 percent virtually, and 21.2 percent alternated between virtual and in person (Graham, 2021). This evaluation comparatively investigates learning loss for the 2021–2022 cohort of prekindergarten students who participated in virtual learning and in-person learning in the prior year. The research questions are as follows:

1. What were the enrollment trends and demographic characteristics of prekindergarten students in HISD in the 2021–2022 school year?
2. Is there a difference in the level of proficiency on the 2021–2022 CIRCLE language arts and literacy and mathematics subtests between prekindergartners who learned remotely or in person in the prior year?
3. Is there a difference in the trend for proficiency on the 2021–2022 CIRCLE language arts and literacy and mathematics subtests between prekindergartners who learned remotely or in person in the prior year?

Methods

Currently, there is only one district-wide assessment administered to prekindergarten students. Consequently, the evaluation used a single source of data for continuous improvement to examine the performance of prekindergarten students who learned in virtually and in-person combined classrooms the previous year. The performance of prekindergarten students who attended SBPs, ECCs, or Charter/Magnet programs were compared across two measures of school readiness: Language and literacy and mathematics proficiency.

Data Source

Information on student demographics, contained in the Public Education Information Management System (PEIMS), was extracted from the OnDataSuite data warehouse. PEIMS data provide a snapshot of students enrolled in HISD as of February 2022. Cognos IBM business intelligence and performance management software suite was used to obtain students' academic performance data.

Measures

Following other preschool studies (Clements, Sarama, Spitler, Lange, & Wolfe, 2011; Wong, Cook, Barnett, & Jung, 2008), a dichotomous set of student-level covariates were used – campus type and at-risk of dropout. Students' ethnicity was captured using a set of categorical variables that identified whether a student was Black (1), Hispanic (2), or Other (0). The variable age at baseline was a continuous variable. The following variables were examined for inclusion into the model and were not selected: gender, economically disadvantaged status, language spoken at home, and prekindergarten program type.

Academic measure. The district uses the CIRCLE online assessment tool designed to monitor academic progress of prekindergarten children ages three years and six months to four years and eleven months. CIRCLE is a standardized, criterion-referenced assessment that was designed to determine prekindergarten students' growth over time in the areas of language arts and literacy and mathematics. Prekindergarten students' academic progress was measured based on three assessment "waves", which occurred at the beginning-of-year (BOY; Wave 1), middle-of-year (MOY; Wave 2), and end-of-year (EOY; Wave 3). Prekindergarten student's progress was measured using three CIRCLE language arts and literacy subtests (rapid letter naming, rapid vocabulary, syllabication) and four mathematics subtests (counting sets, number naming, rote counting, and shape naming). **Appendix A**, **Table A1** (p.11) provides the cut scores for the subtests. Each of the seven 2022 EOY CIRCLE subtest results were used as the outcome variable, a factor with proficient (1) or not proficient (2) levels. In using the binary outcome measure, CIRCLE measures for the Spanish and English tests were aggregated in the analysis.

Predictor. The main predictor of students' proficiency on the language arts and mathematics subtests was learning mode. To be conservative, a remote learner was defined as a student who was marked virtual/remote for more than 50% of the instructional days during the 2020–2021 school year. The subset of students consisted of 53.2 percent remote learners and 46.8 percent in-person learners.

Sample

There were 1,097 prekindergarten students who learned remotely or in person in the previous year and completed a mathematics and/or language arts assessment for the six data points used in this report: beginning of the year (BOY), middle of year (MOY), and the end of the year (EOY) for the 2020–2021 and 2021–2022 school year.

Table 1 (p. 5) presents characteristics of the study population. Of the 1,097 prekindergarten students included in the analyses, more than half of the sample was female (50.9%) and between 4.0 to 4.4 years old at the beginning of the 2021–2022 school year (56.3%). Most of the students were at risk (93.9%), economically disadvantaged (91.6%), and attended a School-based Program (SBP) (58.6%). According to PEIMS, 56.9% of participants were Hispanic, less than 40% of participants were Black/African American and less than 8% of participants were of other ethnicities. Additionally, the PEIMS report indicated that 95% of participants either spoke primarily Spanish (35.7%) or English (58.7%) at home. There was no association between learning mode and age group ($X^2(1) = 0.004$, $p = 0.84$) and gender ($X^2(1) = 0.27$, $p = 0.61$). There was also no association between language tested and learning mode ($X^2(1) = 1.37$, $p = 0.24$).

Statistical analyses

Data were analyzed using Statistical Package for Social Sciences (SPSS) for Windows, Version 28.0.0.0 (SPSS Inc., Chicago, IL). Descriptive analysis of the 2021–2022 cohort of students at baseline was provided. Language and literacy and mathematics scores were examined in relation to students learning mode in the prior year using generalized estimating equations (GEE) regression analysis to analyze the dichotomous outcome variable (proficient or not proficient) using repeated measurements, an unstructured working correlation structure, and treating time as a categorical variable. GEE is a method for modeling longitudinal or clustered data (Owusu-Darko, Adu, & Frempong, 2014; Zeger & Liang, 1986). The data in this study were binary and not symmetrically skewed even after log transformation. GEE is usually used with non-normal data such as binary or count data to create a set of equations that are

solved to obtain parameter estimates (i.e., model coefficients) (Changyong, Hongyue, Naiji, Tian, Hua, & Ying, 2014). Each testing period from 2020–2021 to 2021–2022 academic years were added to the model as a dummy variable (i.e., pre, Test 1 = T1, Test 2 = T2, Test 3 = T3, Test 4 = T4, Test 5 = T5) and the second test period at the start of the school year (2021 MOY) was used as reference category. To assess differences between subgroups on the various CIRCLE assessments, interaction terms between the learning mode and each testing time-point were included in the model. Estimating marginal values are presented as graphs showing trajectories of language arts and mathematics proficiency. Specifically, for each academic subtest GEE regression analysis was used to examine the dichotomous outcome variable (1 = proficient) using repeated measurements and treating time (testing window) as a categorical variable.

Limitations

The academic measures for language arts and mathematics were administered by teachers introducing the possibility of teacher subjectivity (Haslip, 2018) as well as parental subjectivity for those who were tested remotely. Parents or guardians were required to be present at home during testing, while teachers administered the test from a remote classroom. It was reported by educators that parents or caregivers could be heard in the background providing support to students during testing (Graham, 2021). However, multiple measures of mathematics and literacy were used across six time points in a relatively large sample (n = 1,097) representative of all prekindergarten program types in the district. The 2021 BOY was not an ideal baseline for student academic performance since students tested between September 20 and October 20, 2020 – with most students being tested in October after receiving instruction for approximately two months.

Results

What were the enrollment trends and demographic characteristics of prekindergarten students in HISD in the 2021–2022 school year based on prekindergarten campus type (SBP and ECC)?

Based on the PEIMS October 2021 enrollment snapshot, **Figure 3** (p. 6) presents the prekindergarten student enrollment trends for HISD and Texas from 2017–2018 to 2021–2022. The district historically has provided support to approximately 6.1 percent of the overall prekindergarten student population in Texas (Appendix A, **Table A2**, p.11). Prekindergarten students normally account for less than 7 percent of the district's total student population. The number of prekindergarten students in the district showed an increase of 7 percentage points in 2021–2022 from the previous year (11,747 vs. 10,991) (Figure 3). The number of prekindergarten students increased statewide by 13.5 percentage point from the previous year (Appendix A, Table A2, p.11).

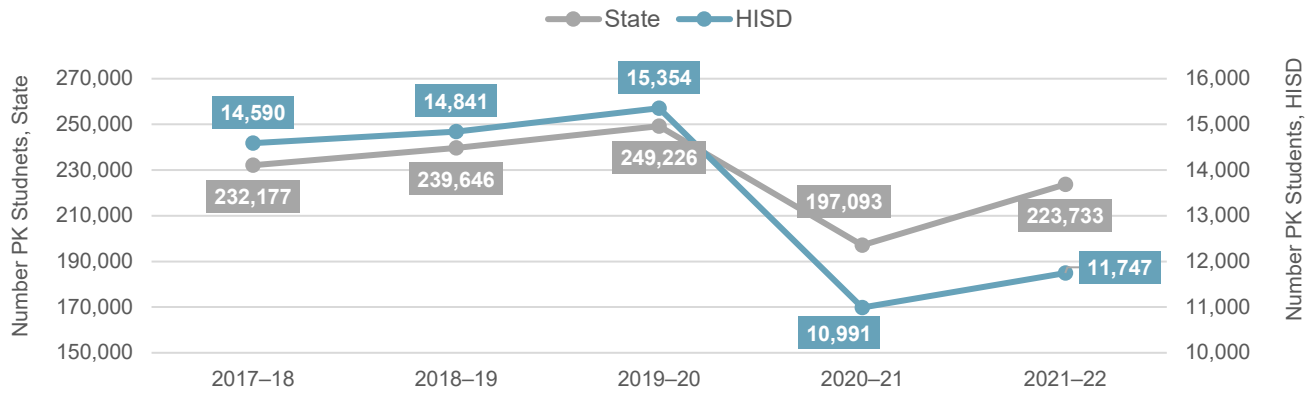
Analysis of the distribution of students by prekindergarten program type for the 2021–2022 school year showed that most prekindergarten students attended school-based programs (SBPs) (74.3%), followed by early childhood centers (ECCs) (19.3%) and charter/ magnet schools (6.4%) (Appendix A, **Table A3**, p.11). A higher

Table 1. Characteristics of Study Population by Learning Mode

	Overall (N=1,097)		In person (n=393)		Remote (n=704)		
	n	%	n	%	n	%	X^2
Test**							
English	934	85.1	328	83.5	606	86.1	1.37
Spanish	163	14.9	65	16.5	98	13.9	
Age Group							
4.5+	479	43.7	170	43.3	309	43.9	0.04
<4.0	618	56.3	223	56.7	395	56.1	
Gender							
Female	558	50.9	204	51.9	354	50.3	0.27
Male	539	49.1	189	48.1	350	49.7	
Ethnicity							
Black	385	35.1	187	47.6	198	28.1	45.13*
Hispanic	624	56.9	173	44	451	64.1	
Other	88	8.0	33	8.4	55	7.8	
Home Language							
English	644	58.7	287	73	357	50.7	52.96*
Spanish	392	35.7	88	22.4	304	43.2	
Other	61	5.6	18	4.6	43	6.1	
Campus Type							
Charter/ ECC/Magnet	454	41.4	146	37.2	308	43.8	4.53*
SBP	643	58.6	247	62.8	396	56.3	
Socio-economic Status							
At-Risk	1030	93.9	367	93.4	663	94.2	0.28
Econ. Dis.	1005	91.6	368	93.6	637	90.5	3.27*

* The Chi-square statistic is significant at the .05 level.
**Test indicates if students completed the subtests in English or Spanish
Econ. Dis.= Economically Disadvantaged

Figure 3: Comparative 5-year Prekindergarten Student Enrollment Trend in HISD and Statewide, 2016–2022



Notes: Data was retrieved from PEIMS Data File, OnDataSuite PEIMS Snapshot for October of each year, 2016–2017 to 2021–2022, state data were retrieved from PEIMS Standard Reports, 2021–22

percentage of males were enrolled at charter/magnet schools (50.9%) compared to ECC (49.4%) and SBPs (49.6%). A comparable percentage of students who attended SBPs (28.0%) and ECCs (28.3%) were Black compared to magnet/charter schools (20.2%). Similarly, the percentage of Hispanic students who attended SBPs (64.0%) and ECCs (69.4%) were higher compared to magnet/charter schools (48.1%) (Appendix A, Table A3, p.11).

When looking at language, 53.3 percent of students whose home language was Spanish attended ECCs and 52.8 percent of student whose home language was English attended SBPs. A larger percentage of students with limited English proficiency (LEP) attended ECCs (54.4%) compared to SBPs (42.6%) and charter/magnet schools (52.9%). Over half of the prekindergarten students that attended ECCs were enrolled in bilingual programs (53.2%). One-third of prekindergarten students who attended a charter/magnet school (34.5%) were enrolled in an EL program (Appendix A, Table A3, p.11).

In terms of socioeconomic status (SES), two thirds of students who attended charter/magnet schools were economically disadvantaged, while almost the whole population of students at ECCs (96.8%) and SBPs (93.2%) were economically disadvantaged. Charter/magnet schools had the lowest percentage of students identified as at risk (69.0%), followed by SBPs (70.5%) and ECCs (79.6%) (Appendix A, Table A3, p.11).

Is there a difference in the level of proficiency on the 2021–2022 CIRCLE language arts and literacy and mathematics subtests between prekindergartners who learned remotely or in person in the prior year?

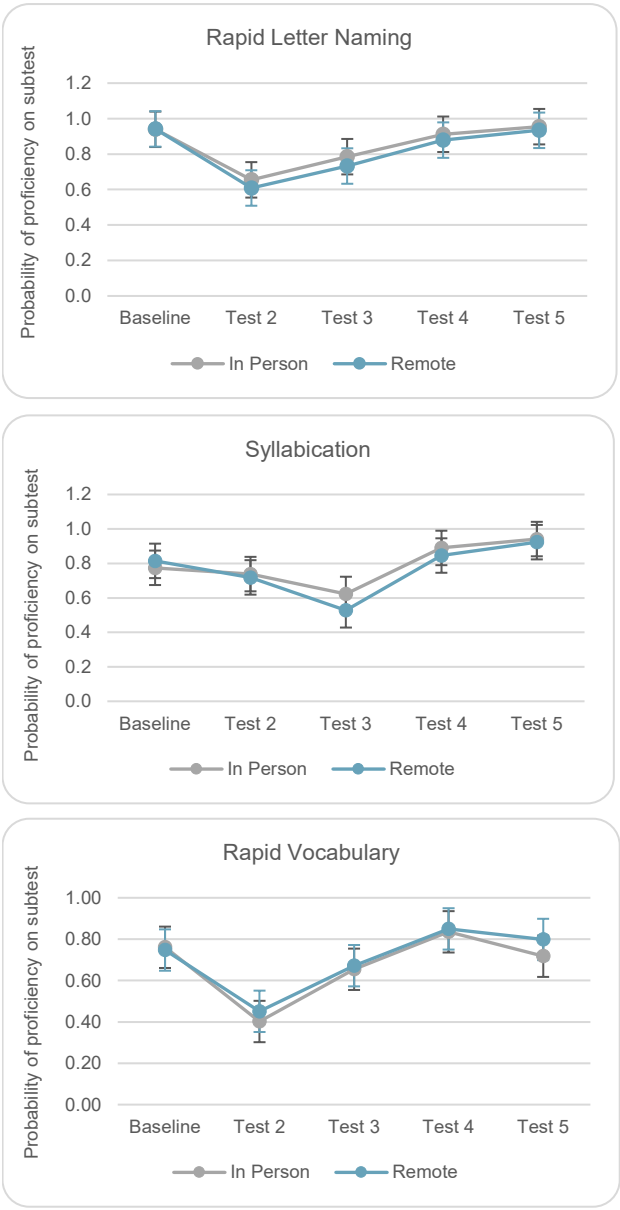
The percentage of remote learners who met proficiency at baseline increased by the end of the year on the rapid letter naming subtests (22.0% and 91.0%, respectively), syllabication subtests (8.1% and 82.6%, respectively), and rapid vocabulary subtests (12.5% and 65.8%, respectively) (**Table A4,** p.12). There were fewer students who met proficiency on rapid vocabulary subtest by the end of year (Table A4, p.12). There was a comparative increase in percentage of in-person learners who met proficiency (Table A4, p.12).

Analysis of descriptive statistics showed that the percentage of students who met proficiency on the rote counting subtest at the baseline and end of the year was relatively low compared to the other subtests (**Table A5,** p.13). The percentage of remote learners who met proficiency at baseline increased by the end of the year on the counting sets subtests (22.5% and 93.3%, respectively), number naming subtests (24.9% and 92.7%, respectively), rote counting subtests (7.1% and 88.7%, respectively), and shape naming subtests (27.6% and 93.1%, respectively) (Table A5, p.13). Compared to remote learners, there was a lower percentage of in-person learners who met proficiency at baseline, but a higher percentage attained proficiency by end of year on all mathematics subtests (Table A5, p.13).

The attainment of language arts and literacy and mathematics proficiency in the total population

gradually improved from the beginning of the 2021–2022 academic year, as shown in **Figure 1** and **Figure 2** (p. 8). Outcome trajectories for improved academic performance on CIRCLE literacy and language arts subtests from the year remote learning was introduced to the year after remote learning was introduced are presented in (Figure 1). Despite lacking precision, evidenced in the overlapping confidence intervals, estimates showed higher probabilities for scoring proficient by the end of the year on rapid letter naming and syllabication subtests for in person learners (Figure 1). The linear trend of proficiency for syllabication subtests showed a slight indication of probability for 'summer slide' from the end of the prior year (T2) to beginning of the next school year (T3), as indicated by the downward slope of the line between the two times (Figure 1). Similarly, the linear trend of proficiency for counting sets, rote counting, and shape naming subtests showed slight indications of probability of 'summer slide' from the end of the prior year (T2) to beginning of the next school year (T3) (Figure 2). At the baseline, there was a difference between remote learners and in person learners' probability of scoring proficient on the counting sets, however, on the shape naming subtests learning mode appears to show little difference in the probability of scoring proficient by the end of the year.

Figure 1. Longitudinal Association Between Remote Learning and Measures of Literacy and Language Arts Proficiency on CIRCLE



Is there a difference in the trend for proficiency on the 2021–2022 CIRCLE language arts and literacy and mathematics subtests between prekindergartners who learned remotely or in person in the prior year?

There was an effect for learning mode and the odds of scoring proficient on rapid vocabulary subtests (**Table A6**, p. 14). The odds of passing the rapid vocabulary subtest were higher for in person learners than remote learners. Prekindergarten students who participated in remote learning were 46 percent more likely to pass the rapid vocabulary subtest for each unit increase in test ($p < .05$). While those students who learned in person were 54 percent more likely to pass the rapid vocabulary subtest for each unit increase in test.

The association between learning mode and proficiency scores in mathematics for prekindergarten students are presented in **Table A7** (p. 14). It was observed that there was no difference in the odds of scoring proficient on CIRCLE mathematics subtests for remote and in-person learners, except for the rote counting subtests. Prekindergarten students who participated in remote learning were 31 percent less likely to pass the rote counting subtest for each unit increase in test, while in person learners were 25 percent less likely ($p < .05$).

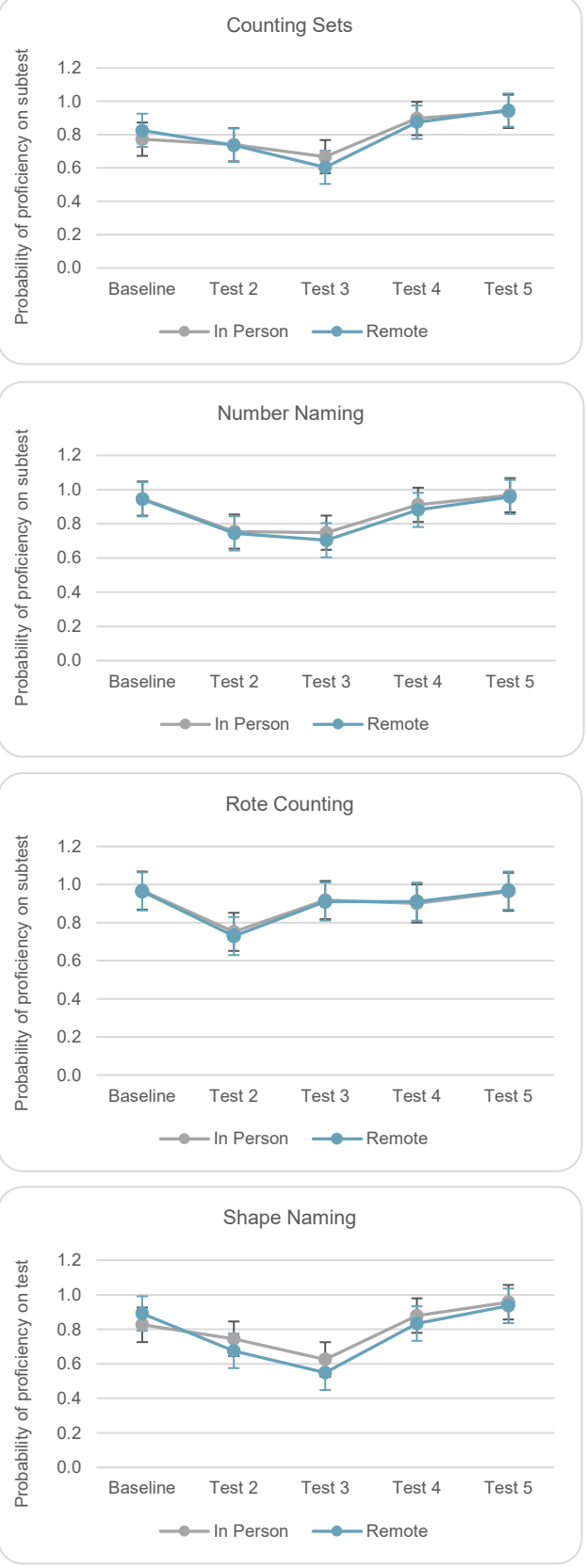
There was a significant effect for the pretest on the four mathematics subtests (Table A7, p. 14). For example, those who were proficient on the pretest for rote counting were 24 times more likely to score proficient for every unit increase in test

periods (p <.001). Similarly, proficiency at baseline on number naming subtests increased likelihood attaining proficiency 16 times for every unit increase in test periods (p <.001). Lower levels of proficiency were observed for prekindergarten students who were proficient at the baseline on counting sets and shape naming. The odds of attaining proficiency were 4 times higher for counting sets and 7 times higher for shape naming subtests for every unit increase in test periods (p <.001).

Finally, there was also a significant testing effect on ethnicity when controlling for pretest scores and remote learning for each subtest. Ethnicity effects the odds of scoring proficient on the rapid letter naming subtests (Table A6, p. 14). There were lower odds of scoring proficient on rapid letter naming subtests for students who identified as Black (OR = 0.36, p <.05, C.I. 0.2–0.6) or Hispanic (OR = 0.39, p <.05, C.I. 0.2–0.7) compared to their counterparts. For mathematics, the odds of attaining proficiency for Black and Hispanic students decreased on average fifty percent for every unit increase in test periods on counting sets and number naming subtests compared to their counterparts (p <.05) (Table A7, p. 14). There was only an effect for Hispanic students on the rote counting subtests, with a decreased likelihood of 50 percent (p <.05). The odds ratio for age indicates that every year increase in age was associated with increased odds of scoring proficient on the counting sets subtests (OR = 16.21, p<.000, C.I. 9.02–29.10), number naming subtests (OR = 16.21, p<.000, C.I. 9.02–29.10), rote counting subtest (OR = 4.39, p<.000, C.I. 2.58–7.48), and shape naming subtests (OR = 4.39, p<.000, C.I. 2.58–7.48).

There was a significant effect for gender and economic disadvantaged status on several of the mathematics subtests (Table A7, p. 14). For example, female students, compared to male students, were 22 percent less likely to score proficient on counting sets and 24 percent less likely to score proficient on rote counting for every unit increase in test periods (p <.05). Conversely, on the rote counting subtests there was a 14 percent increase in likelihood of scoring proficient compared to their counterparts(p <.05). Economic disadvantaged students had a decreased odds of passing the counting sets (OR = 2.75, p <.05, C.I. 1.9–3.9), number naming (OR = 2.33, p <.05, C.I. 1.6–3.4), and shape naming (OR = 2.17, p <.05,

Figure 2. Longitudinal Association Between Remote Learning and Measures of Mathematics Proficiency on CIRCLE



C.I. 1.5–3.1) subtests compared to their counterparts.

The older the student, the more likely they will score proficient on the subtests. The odds ratio for age indicates that every year increase in age is associated with increased odds of scoring proficient on the rapid letter naming subtests (OR = 2.64, $p < .05$, C.I. 1.8–3.9), syllabication subtests (OR = 2.42, $p < .05$, C.I. 1.8–3.3), and rapid vocabulary subtests (OR = 2.50, $p < .05$, C.I. 1.9–3.4) (Table A6, p. 14). There also exists an association between age and proficiency on mathematics subtests (Table A7, p. 14). Every year increase in age is associated with increased odds of scoring proficient on the counting sets subtest subtests (OR = 2.75, $p < .05$, C.I. 1.9–3.9), number naming subtests (OR = 2.33, $p < .05$, C.I. 1.6–3.4), rote counting subtests (OR = 2.55, $p < .05$, C.I. 1.8–3.7) and shape naming subtests (OR = 2.17, $p < .05$, C.I. 1.5–3.1).

Discussion

The principal hypothesis of this study was that students who participated in person learning in the prior year would have significant academic growth in the subsequent year compared to those who learned remotely. Specifically, it was predicted that in-person learners would continue to demonstrate more extensive mathematical and language arts proficiency on the CIRCLE assessments than remote learners (Graham, 2021).

Research has found that learning loss can be observed with any interruption in schooling attributed to a wide range of occurrences, from possible summer slide to the pandemic (Schwartz, Ahmed, Leschitz, Uzicanin, & Uscher-Pines, 2020). The results of this study contribute to the literature by suggesting overall there was little to no difference in learning outcomes for those who learned in person or remotely, however there were ethnic and age differences among remote and in person learners on several subtests.

When disaggregated by subtests, there was an association between ethnicity, gender, and odds of scoring proficient on the mathematics and language arts and literacy subtests. Hispanic students showed lower odds of scoring proficient on rapid letter naming, number naming, rote counting, and shape naming subtests ($p < .05$) compared to their counterparts. While Black students showed lower odds of scoring proficient on rapid letter naming, number naming, and shape naming ($p < .05$). For language arts and literacy, there was only an association between ethnicity and the odds of scoring proficient on the rapid letter naming subtests ($p < .05$). There were lower odds of scoring proficient on rapid letter naming subtests for students who identified as Black (OR = 0.36, $p < .05$, C.I. 0.2–0.6) or Hispanic (OR = 0.39, $p < .05$, C.I. 0.2–0.7) compared to their counterparts.

Similarly, there was a significant association between students' economic disadvantaged status and scoring proficient on the mathematics subtests ($p \leq .001$), except for shape naming ($p = .84$). There was an association between gender and odds of attaining a passing score on counting sets and rote counting ($p < .005$). Female students had an increased odds of passing these subtests than their male counterpart. There was no association between economic disadvantaged status or gender and the language arts and literacy subtests.

Recommendations

When considering all three language arts and literacy (rapid vocabulary, rapid letter naming, and syllabication) and mathematics (counting sets, number naming, rote counting, and shape naming) measures together across the six testing periods, remote learning in the prior year showed a small association with prekindergartners language arts and literacy and mathematics achievement in 2021–2022. It was observed that rates of proficiency were slightly lower for remote learners across most of the subtests. There was therefore no clear indication of association between learning mode and student performance on various language arts and literacy and mathematics subtests in this sample although the data suggests there may be ethnic and age specific associations. Though the findings varied by subject, they were in alignment with prior research (Kuhfeld & Tarasawa, 2020). It was found that the negative impacts of school closure were predicted to be greater for Hispanic and Black students and economic disadvantaged students on most mathematics subtests when controlling for learning mode and gender. Further investigation is required to examine the long-term impact of school closures on the process of developing the foundational skills in math and language arts needed for long term success for this population of early learners.

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APPENDIX A

Table A1. Cut Scores for CIRCLE Subtests Administered to HISD Students in the 2019–2020 School Year

		3.0 - <3.5		3.5 - <4.0		4.0 - <4.5		4.5 or above	
	SUBTESTS	English	Spanish	English	Spanish	English	Spanish	English	Spanish
LANGUAGE AND LITERACY	Rapid Letter Naming	***	***	8	6	14	10	14	13
	Rapid Vocabulary	10	7	12	9	19	16	20	16
	Phonological Awareness Total Score*	9	7	12	11	15	13	17	15
	Syllabication*	***	***	6	5	6	5	6	5
	Alliteration*	***	***	6	5	6	5	6	5
	Words in a Sentence*	***	***	4	3	4	3	4	3
	Rhyming I*	***	***	7	5	7	5	7	5
MATHEMATICS	Math Total Score	11	10	13	13	18	17	20	20
	Rote Counting	***	***	2	2	2	2	2	2
	Shape Naming	***	***	4	4	4	4	4	4
	Number Discrimination	***	***	2	2	2	2	2	2
	Number Naming	***	***	3	3	3	3	3	3
	Shape Discrimination	***	***	5	5	5	5	5	5
	Counting Sets	***	***	4	4	4	4	4	4

Source. Adapted from Children's Learning Institute (August 2018). CIRCLE Progress Monitoring Cut Points. University of Texas Children's Learning Institute: Houston, TX.
Note. If a student scores at or above cut points determined for a particular measure, they are considered proficient. If a student scores below the benchmark, they are considered 'developing' (refers to students younger than four years old) or 'emerging' (for students four years old and older). Those age groups with not cut points are identified as *** and those subtests that are not administered in Spanish have a dash (-).

Table A2. Comparative 6-year Prekindergarten Student Enrollment Trend in HISD and Statewide, 2016–2022

	PK Enrollment				6-year change	
	HISD (N)	% of HISD Student Population	State (N)	HISD PK as % of state PK Population	HISD % Change	State % Change
2015–16	14,824	6.9	222,000	6.7	–	–
2016–17	14,686	6.8	224,810	6.5	-0.9%	1.3%
2017–18	14,590	6.8	232,177	6.3	-0.7%	3.3%
2018–19	14,841	7.1	239,646	6.2	1.7%	3.2%
2019–20	15,354	7.3	249,226	6.2	3.5%	4.0%
2020–21	10,991	5.6	197,093	5.6	-28.4%	-20.9%
2021–22	11,747	6.0	223,733	5.3	6.9%	13.5%

Notes: Data was retrieved from PEIMS Data File, OnData Suite PEIMS Snapshot for October of each year, 2016–2017 to 2020–2021, state data was retrieved from PEIMS Standard Reports, 2020-21

Table A3: Prekindergarten Student Demographics by Campus Type, Percentage, 2021–2022

		HISD Charter/ Magnet Program		HISD Early Childhood Center (ECC)		HISD School Based Program (SBP)	
		n	%	n	%	n	%
Overall Population (N)		746	6.4	2,270	19.3	8,730	74.3
Gender	Female	366	49.1%	1,149	50.6%	4,400	50.4%
	Male	380	50.9%	1,121	49.4%	4,330	49.6%
Ethnicity	Black	151	20.2%	642	28.3%	2,441	28.0%
	Hispanic	359	48.1%	1,575	69.4%	5,590	64.0%
	Other	236	31.6%	53	2.3%	699	8.0%
Home Language	Spanish	251	33.6%	1,209	53.3%	3,693	42.3%
	English	326	43.7%	1,009	44.4%	4,612	52.8%
	Other	169	22.7%	52	2.3%	425	4.9%
Socio-econ. Status	Economic Disadvantaged	486	65.1%	2,197	96.8%	8,138	93.2%
	At-risk	515	69.0%	1,807	79.6%	6,159	70.5%
Programs	Limited English Proficiency (LEP)	395	52.9%	1,236	54.4%	3,715	42.6%
	Bilingual Program	197	26.4%	1,208	53.2%	3,208	36.7%
	Emergent Bilingual (EB)	257	34.5%	81	3.6%	560	6.4%

Table A4. Percentage of Students Who Scored Proficient on Each Language Arts and Literacy Subset by Testing Window (Time)

Outcome Measure [Proficiency on Subtest=1]		Baseline BOY 2019–20	Test 1 MOY 2019–20	Test 2 EOY 2019–20	Test 3 BOY 2020–21	Test 4 MOY 2020–21	Test 5 EOY 2020-21
Rapid Letter Naming (n=959) (n, %)							
Campus Type	Other (ECC/ Magnet)	93, (22.9)	214, (52.7)	254, (62.6)	302, (74.4)	370, (91.1)	385, (94.8)
	School Based Program	95, (17.2)	259, (46.8)	325, (58.8)	390, (70.5)	461, (83.4)	503, (91.0)
Gender	Male	89, (19.4)	231, (50.3)	278, (60.6)	318, (69.3)	395, (86.1)	424, (92.4)
	Female	99, (19.8)	242, (48.4)	301, (60.2)	374, (74.8)	436, (87.2)	464, (92.8)
Ethnicity	Other	29, (42.6)	48, (70.6)	57, (83.8)	66, (97.1)	67, (98.5)	67, (98.5)
	Black	88, (28.4)	160, (51.6)	180, (58.1)	232, (74.8)	270, (87.1)	288, (92.9)
	Hispanic	71, (12.2)	265, (45.6)	342, (58.9)	394, (67.8)	494, (85.0)	533, (91.7)
At-Risk	No	17, (48.6)	25, (71.4)	26, (74.3)	28, (80.0)	31, (88.6)	33, (94.3)
	Yes	171, (18.5)	448, (48.5)	553, (59.8)	664, (71.9)	800, (86.6)	855, (92.5)
Remote	No	78, (17.0)	229, (50.0)	290, (63.3)	347, (75.8)	409, (89.3)	432, (94.3)
	Yes	110, (22.0)	244, (48.7)	289, (57.7)	345, (68.9)	422, (84.2)	456, (91.0)
Syllabication (n=975) (n, %)							
Campus Type	Other (ECC/ Magnet)	38, (9.3)	120, (29.3)	228, (55.7)	141, (34.5)	304, (74.3)	348, (85.1)
	School Based Program	34, (6.0)	170, (30.0)	277, (48.9)	210, (37.1)	396, (70.0)	471, (83.2)
Gender	Male	34, (7.3)	138, (29.8)	235, (50.8)	149, (32.2)	325, (70.2)	394, (85.1)
	Female	38, (7.4)	152, (29.7)	270, (52.7)	202, (39.5)	375, (73.2)	425, (83.0)
Ethnicity	Other	10, (14.5)	25, (36.2)	42, (60.9)	36, (52.2)	51, (73.9)	58, (84.1)
	Black	30, (9.5)	99, (31.4)	152, (48.3)	124, (39.4)	218, (69.2)	255, (81.0)
	Hispanic	32, (5.4)	166, (28.1)	311, (52.6)	191, (32.3)	431, (72.9)	506, (85.6)
At-Risk	No	5, (14.3)	15, (42.9)	18, (51.4)	17, (48.6)	25, (71.4)	29, (82.9)
	Yes	67, (7.1)	275, (29.3)	487, (51.8)	334, (35.5)	675, (71.8)	790, (84.0)
Remote	No	30, (6.6)	134, (29.3)	240, (52.4)	183, (40.0)	345, (75.3)	392, (85.6)
	Yes	42, (8.1)	156, (30.2)	265, (51.3)	168, (32.5)	355, (68.7)	427, (82.6)
Rapid Vocabulary (n=974) (n, %)							
Campus Type	Other (ECC/ Magnet)	70, (17.3)	158, (39.0)	146, (36)	224, (55.3)	317, (78.3)	283, (69.9)
	School Based Program	65, (11.4)	229, (40.2)	180, (31.6)	316, (55.5)	426, (74.9)	365, (64.1)
Gender	Male	64, (14.1)	190, (41.8)	151, (33.2)	246, (54.1)	341, (74.9)	293, (64.4)
	Female	71, (13.7)	197, (38.0)	175, (33.7)	294, (56.6)	402, (77.5)	355, (68.4)
Ethnicity	Other	15, (21.7)	29, (42.0)	20, (29.0)	47, (68.1)	59, (85.5)	40, (58.0)
	Black	45, (14.5)	119, (38.4)	80, (25.8)	207, (66.8)	247, (79.7)	194, (62.6)
	Hispanic	75, (12.6)	239, (40.2)	226, (38.0)	286, (48.1)	437, (73.4)	414, (69.6)
At-Risk	No	9, (25.7)	16, (45.7)	10, (28.6)	27, (77.1)	32, (91.4)	29, (82.9)
	Yes	126, (13.4)	371, (39.5)	316, (33.7)	513, (54.6)	711, (75.7)	619, (65.9)
Remote	No	70, (15.4)	210, (46.3)	170, (37.4)	277, (61.0)	363, (80.0)	306, (67.4)
	Yes	65, (12.5)	177, (34.0)	156, (30.0)	263, (50.6)	380, (73.1)	342, (65.8)

Table A5. Percentage of Students Who Scored Proficient on Each Mathematics Subset by Testing Window (Time)

Outcome Measure [Proficiency on Subtest=1]		Baseline BOY 2019–20	Test 1 MOY 2019–20	Test 2 EOY 2019–20	Test 3 BOY 2020–21	Test 4 MOY 2020–21	Test 5 EOY 2020-21
Counting Sets (n=958) (n, %)							
Campus Type	Other (ECC/ Magnet)	91, (22.1)	213, (51.7)	302, (73.3)	263, (63.8)	369, (89.6)	394, (95.6)
	School Based Program	80, (14.7)	256, (46.9)	380, (69.6)	322, (59.0)	460, (84.2)	500, (91.6)
Gender	Male	80, (17.8)	211, (47.0)	313, (69.7)	266, (59.2)	377, (84.0)	416, (92.7)
	Female	91, (17.9)	258, (50.7)	369, (72.5)	319, (62.7)	452, (88.8)	478, (93.9)
Ethnicity	Other	29, (41.4)	49, (70.0)	53, (75.7)	59, (84.3)	67, (95.7)	68, (97.1)
	Black	76, (25.8)	152, (51.5)	209, (70.8)	185, (62.7)	249, (84.4)	271, (91.9)
	Hispanic	64, (10.8)	266, (45.0)	418, (70.7)	339, (57.4)	511, (86.5)	553, (93.6)
At-Risk	No	11, (31.4)	20, (57.1)	25, (71.4)	26, (74.3)	30, (85.7)	33, (94.3)
	Yes	160, (17.3)	449, (48.6)	657, (71.2)	559, (60.6)	799, (86.6)	861, (93.3)
Remote	No	64, (14.7)	221, (50.7)	318, (72.9)	288, (66.1)	387, (88.8)	407, (93.3)
	Yes	107, (20.5)	248, (47.5)	364, (69.7)	297, (56.9)	442, (84.7)	487, (93.3)
Number Naming (n=960) (n, %)							
Campus Type	Other (ECC/ Magnet)	95, (23.1)	194, (47.1)	284, (68.9)	273, (66.3)	361, (87.6)	398, (96.6)
	School Based Program	96, (17.5)	221, (40.3)	339, (61.9)	327, (59.7)	434, (79.2)	495, (90.3)
Gender	Male	91, (20.3)	199, (44.3)	303, (67.5)	288, (64.1)	379, (84.4)	422, (94.0)
	Female	100, (19.6)	216, (42.3)	320, (62.6)	312, (61.1)	416, (81.4)	471, (92.2)
Ethnicity	Other	28, (41.2)	47, (69.1)	60, (88.2)	60, (88.2)	67, (98.5)	67, (98.5)
	Black	81, (27.2)	148, (49.7)	197, (66.1)	199, (66.8)	247, (82.9)	276, (92.6)
	Hispanic	82, (13.8)	220, (37)	366, (61.6)	341, (57.4)	481, (81.0)	550, (92.6)
At-Risk	No	16, (45.7)	23, (65.7)	28, (80.0)	28, (80.0)	32, (91.4)	34, (97.1)
	Yes	175, (18.9)	392, (42.4)	595, (64.3)	572, (61.8)	763, (82.5)	859, (92.9)
Remote	No	62, (14.1)	176, (39.9)	279, (63.3)	276, (62.6)	370, (83.9)	412, (93.4)
	Yes	129, (24.9)	239, (46.1)	344, (66.3)	324, (62.4)	425, (81.9)	481, (92.7)
Rote Counting (n=966) (n, %)							
Campus Type	Other (ECC/ Magnet)	28, (7.0)	124, (30.9)	213, (53.1)	305, (76.1)	311, (77.6)	369, (92.0)
	School Based Program	31, (5.5)	139, (24.6)	252, (44.6)	429, (75.9)	406, (71.9)	491, (86.9)
Gender	Male	31, (6.8)	123, (27.1)	213, (46.9)	330, (72.7)	325, (71.6)	399, (87.9)
	Female	28, (5.5)	140, (27.3)	252, (49.2)	404, (78.9)	392, (76.6)	461, (90.0)
Ethnicity	Other	10, (14.1)	31, (43.7)	40, (56.3)	63, (88.7)	62, (87.3)	67, (94.4)
	Black	31, (10.3)	105, (34.9)	172, (57.1)	248, (82.4)	231, (76.7)	274, (91.0)
	Hispanic	18, (3.0)	127, (21.4)	253, (42.6)	423, (71.2)	424, (71.4)	519, (87.4)
At-Risk	No	12, (34.3)	19, (54.3)	22, (62.9)	28, (80.0)	28, (80.0)	32, (91.4)
	Yes	47, (5.0)	244, (26.2)	443, (47.6)	706, (75.8)	689, (74.0)	828, (88.9)
Remote	No	22, (4.9)	131, (29.4)	235, (52.8)	353, (79.3)	337, (75.7)	398, (89.4)
	Yes	37, (7.1)	132, (25.3)	230, (44.1)	381, (73.1)	380, (72.9)	462, (88.7)
Shape Naming (n=969) (n, %)							
Campus Type	Other (ECC/ Magnet)	117, (28.3)	240, (58.0)	312, (75.4)	276, (66.7)	370, (89.4)	401, (96.9)
	School Based Program	121, (21.8)	273, (49.2)	375, (67.6)	307, (55.3)	451, (81.3)	510, (91.9)
Gender	Male	120, (26.6)	250, (55.4)	324, (71.8)	277, (61.4)	386, (85.6)	429, (95.1)
	Female	118, (22.8)	263, (50.8)	363, (70.1)	306, (59.1)	435, (84.0)	482, (93.1)
Ethnicity	Other	42, (60.0)	56, (80.0)	65, (92.9)	58, (82.9)	67, (95.7)	68, (97.1)
	Black	93, (30.9)	172, (57.1)	213, (70.8)	200, (66.4)	264, (87.7)	286, (95.0)
	Hispanic	103, (17.2)	285, (47.7)	409, (68.4)	325, (54.3)	490, (81.9)	557, (93.1)
At-Risk	No	19, (52.8)	26, (72.2)	30, (83.3)	29, (80.6)	33, (91.7)	35, (97.2)
	Yes	219, (23.5)	487, (52.2)	657, (70.4)	554, (59.4)	788, (84.5)	876, (93.9)
Remote	No	94, (21.0)	230, (51.5)	329, (73.6)	280, (62.6)	388, (86.8)	425, (95.1)
	Yes	144, (27.6)	283, (54.2)	358, (68.6)	303, (58.0)	433, (83.0)	486, (93.1)

Table A6. Odds Ratios from Generalized Estimating Equations (GEE) Models Predicting Proficiency on CIRCLE Mathematics Subtests, Testing Window 1–6

	Rapid Letter Naming n = 943		Syllabication n = 966		Rapid Vocabulary n = 962	
Variable	Adj. OR	95% CI	Adj. OR	95% CI	Adj. OR	95% CI
Baseline	16.69	(10.5, 26.6)†	3.95	(2.7, 5.9)*	3.16	(2.5, 4.1) †
Remote (ref =In person)	0.89	(0.6, 1.3)	1.02	(0.7, 1.4)	0.54	(0.4, 0.7)*
Tests	2.11	(1.9, 2.3) †	1.90	(1.8, 2.0)†	1.39	(1.3, 1.5) †
Remote * Tests	0.90	(0.8, 1.0)	0.93	(0.9, 1.0)	1.11	(1.0, 1.2)*
Gender (ref=male)	1.03	(0.8, 1.3)	1.09	(0.9, 1.3)	1.05	(0.9, 1.2)
Ethnicity						
BLACK	0.36	(0.2, 0.6)*	0.71	(0.5, 1.1)	1.08	(0.7, 1.6)
HISPANIC	0.39	(0.2, 0.7)*	0.73	(0.5, 1.1)	1.06	(0.7, 1.5)
Economic Disadvantaged	0.87	(0.6, 1.4)	0.94	(0.7, 1.3)	0.73	(0.5, 1.1)
Age	2.64	(1.8, 3.9)*	2.42	(1.8, 3.3)*	2.50	(1.9, 3.4)*

*$p < .05$, †$p < .001$

Table A7. Odds Ratios from Generalized Estimating Equations (GEE) Models Predicting Proficiency on CIRCLE Language Arts and Literacy Subtests, Testing Window 1–6

	Counting Sets n = 952		Number Naming n = 954		Rote Counting n = 959		Shape Naming n = 963	
	Adj. OR	95% CI	Adj. OR	95% CI	Adj. OR	95% CI	Adj. OR	95% CI
Baseline	4.09	(2.9, 5.9)*	16.54	(9.9, 27.6) †	23.72	(11.3, 49.6) †	7.06	(5, 10) †
Remote (ref =In person)	0.77	(0.6, 1.1)	1.07	(0.8, 1.5)	0.69	(0.5, 1.0)*	1.02	(0.7, 1.4)
Tests	1.88	(1.7, 2) †	2.14	(2, 2.3)**	2.22	(2.0, 2.4)**	1.90	(1.8, 2.0) †
Remote * Tests	0.99	(0.9, 1.1)	0.93	(0.8, 1)	1.04	(0.9, 1.2)	0.91	(0.8, 1.0)
Gender (ref=male)	1.22	(1, 1.5)*	0.86	(0.7, 1.1)	1.24	(1.0, 1.5)*	0.91	(0.7, 1.1)
Ethnicity								
BLACK	0.62	(0.4, 1)	0.44	(0.2, 0.8)*	0.86	(0.5, 1.4)	0.50	(0.3, 0.9)*
HISPANIC	0.62	(0.4, 1)*	0.38	(0.2, 0.7)*	0.53	(0.3, 0.8)*	0.41	(0.2, 0.7)*
Economic Disadvantaged	0.50	(0.3, 0.8)*	0.62	(0.4, 1)*	0.65	(0.4, 1.0)*	0.96	(0.6, 1.5)
Age	2.75	(1.9, 3.9)*	2.33	(1.6, 3.4)*	2.55	(1.8, 3.7)*	2.17	(1.5, 3.1)*

*$p < .05$, †$p < .001$