

**TECHNICAL BRIEF**

**Technical appendix for:  
“Behind at the starting line: What kindergarten test  
scores tell us about reaching proficiency in 3<sup>rd</sup> grade”**

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## 1. Introduction

The purpose of this technical appendix is to share detailed results and to more fully describe the sample and methods used in the research included in the brief *Behind at the starting line: What kindergarten test scores tell us about reaching proficiency in 3<sup>rd</sup> grade*. We investigated two main research questions in this brief:

1. How strongly do achievement levels at kindergarten entry predict later proficiency?
2. How likely is it for students who struggle in the early grades to catch up and reach proficiency by third grade?

## 2. Data

### Sample

The data for this study are from the NWEA anonymized longitudinal student achievement database. School districts use [NWEA® MAP® Growth™](#) assessments to monitor elementary and secondary students' reading and math achievement and gains, with assessments typically administered in the fall (usually between August and November), winter (December to March), and spring (late March through June). The NWEA data also include demographic information, including student race/ethnicity, gender, and age at assessment. An indicator of student-level socioeconomic status is not available. However, a set of school-level characteristics, including school-level free or reduced priced lunch (FRPL) eligibility was obtained from the 2023-24 school-level [Common Core of Data \(CCD\)](#) files from the National Center for Education Statistics.

We follow students in the kindergarten class of 2021-22 across four school years. We required that students were tested in fall 2021 (kindergarten entry) to be included, but students were not required to be observed across all terms in the study. In total, our sample includes approximately 446,000 K-3 students with math test scores and 373,000 students with reading test scores. Table 1 describes the demographic characteristics of the K-3 students in our sample. Approximately 45% of our sample is White, 16% is Black, 24% is Hispanic, and 4% is Asian.

The nearly 7,600 schools with K-3 test-takers in this sample represent roughly 13% of the U.S. public schools that enroll kindergarten to 3<sup>rd</sup> grade students. Table 2 compares our sample of NWEA schools relative to the population of U.S. public schools. The NWEA sample reflects schools serving a slightly higher percentage of urban schools and slightly higher percentage of students eligible for FRPL.

### Measure of achievement

Student test scores from the NWEA MAP Growth reading and math assessments, called RIT scores, were used in this study. MAP Growth is a computer adaptive test that precisely measures achievement, even for students above or below grade level and is vertically scaled to allow for the estimation of gains across time. MAP Growth assessments are typically administered three times a year (fall, winter, and spring) and are aligned to state content

standards. Test scores are reported on the RIT (Rasch unit) scale<sup>1</sup>, which is a linear transformation of the logit scale units from the Rasch item response theory model. MAP Growth test scores are highly reliable across all grade levels, with marginal reliability estimates ranging from .90 to .96 (see Table 3).

### **Quintile calculation**

In this study, achievement percentiles were calculated based on the [2025 MAP Growth norms](#). Since MAP Growth can be administered at any point during the school year, the MAP Growth achievement norms condition on each student's grade, subject, and instructional week of testing (i.e., the week in the school calendar in which a student tested). Instructional weeks were calculated for each student based on their school start date and the individual student's testing dates (for more details on the calculation of instructional weeks, see the norms study).

To calculate achievement percentiles, we first standardized students' RIT scores ( $Y_{it}$ ) using the predicted mean ( $\hat{Y}_t$ ) and standard deviation ( $SD(Y_t)$ ) for a given grade, subject, and instructional week ( $t$ ) combination found in the NWEA norms model (see 2025 MAP Growth Norms Technical Manual):

$$z(Y_{it}) = \frac{(Y_{it} - \hat{Y}_t)}{SD(Y_t)}$$

From the standardized score, we calculated the score percentile (e.g., the proportion of the distribution with scores less than or equal to the student's score):

$$p_s(Y_{it}) = Pr(Y_{it} \leq y_t) = \int_{-\infty}^{y_t} \phi(z) dz,$$

where  $\phi(z)$  represents the probability density function. The student normative percentile used in this study was scaled to range from 1 to 99:

$$\text{Perc} = 100 \times p_s(Y_{it}).$$

Percentile scores were binned into quintiles using the following groups: (A) Quintile 1: 1-20th percentile, Quintile 2: 21-40th percentile, Quintile 3: 41-60th percentile, Quintile 4: 61-80th percentile, and Quintile 5: 81-99th percentile.

### **Third grade proficiency cut score**

States define grade-level proficiency relative to their own state standards and summative test cut scores. NWEA conducts [linking studies](#) to estimate the MAP Growth scores associated with the proficiency cut scores from state summative assessments. States vary widely in the score associated with meeting grade-level proficiency or advanced performance levels. Given this variability, NWEA produces a set of [default cut scores](#) that can be used by partners to classify students into three performance levels (off track for grade-level proficiency, on-track for grade-level proficiency, and on track for advanced level). These cut scores are based on the median of all available individual state linking studies for mathematics and reading in grades 3-8. As such, they can be seen as the middle-ground benchmark for grade-level proficiency for all states. For third grade, this proficiency cut score corresponds to the 64<sup>th</sup> percentile in math and the 65<sup>th</sup> percentile in reading.

### **Missing data**

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<sup>1</sup> In the 2023-24 school year, NWEA began the phased implementation of an enhanced item-selection algorithm for the MAP Growth assessment. The [enhanced item-selection algorithm \(EISA\)](#) prioritizes grade-level content while still adapting to off-grade items where necessary to provide items of appropriate difficulty for students. All scores in this study are converted to be on the EISA scale.

We observed moderately high attrition over the course of the four years (40% of students with kindergarten fall scores were not observed in 3<sup>rd</sup> grade spring). One major concern in this study is that we might see differential attrition between K and 3<sup>rd</sup> grade for students at the bottom or top of the distribution. Therefore, we used multiple imputation methods implemented in the *mice* package in R to impute test scores for students whose test scores at later timepoints were missing. We imputed ten datasets per subject conditional on students' entire score trajectory, instructional weeks per grade/term, race/ethnicity, and gender.

Our results were quite similar between the observed and imputed samples. We present results from the imputed samples in the brief (observed sample findings are available upon request).

### 3. Methods

#### **RQ1: How strongly do achievement levels at kindergarten entry predict later proficiency?**

Table 3 shows the descriptive statistics for the MAP Growth scores from the fall of kindergarten (fall 2021) to the spring of third grade (spring 2025). The correlations across terms are high, with correlations of .66 to .86 for adjacent terms. The correlation between fall K and spring of third grade is .52 in reading and .63 in math.

Table 4 shows the percentage of students scoring in each quintile in the spring of third grade based on their initial achievement quintile in earlier terms. For example, the first five rows of the Math KF column show the percentage of students who started in the lowest quintile in the fall of kindergarten that are in Q1-Q5 in spring of third grade, whereas the first five rows of Math 3F column show the percentage of students who started in the lowest quintile in the fall of third grade that are in Q1-Q5 in spring of third grade. We observe that students who start in the bottom or top quintile tend to stay there.

#### **RQ2: How likely is it for students who struggle in the early grades to catch up and reach proficiency by third grade?**

Table 5 presents the percentage of students reaching proficiency in the spring of third grade based on their initial achievement quintile in fall K through the spring of third grade. As seen in Figures 2 & 3 in the brief, the percentage of bottom-quintile students reaching proficiency generally decreases as students move through grade levels.

### 4. Comparison with Prior Studies

Finally, we compared our estimates to existing studies looking at the predictive validity of other kindergarten readiness assessments (KRAs) to identify students reaching proficiency in 3<sup>rd</sup> grade. Specifically, we focused on the percentage of students who are categorized as off-track (or another similar categorization) in kindergarten who reach proficiency in 3<sup>rd</sup> grade. Table 6 shows the results of this comparison. Our results are quite similar to the reported proficiency rates for off-track students based on the Maryland and Illinois KRAs but notably lower than results reported based on a Virginia literacy screener and Amplify's mCLASS measure.

**Table 1. Student characteristics for K-3 cohorts**

Subject	Counts			Race/ethnicity Percentages							
	Students	Schools	Districts	Male	White	Black	Hispanic	Asian	AIAN	Multi-ethnic	Other Race
Math	446,344	7,598	2,517	51%	44%	16%	25%	4%	1%	5%	4%
Reading	372,726	6,767	2,407	51%	46%	17%	22%	4%	1%	5%	5%

Note. AIAN= American Indian or Alaska Native.

**Table 2. Sample school descriptive statistics relative to U.S. population of schools serving students in K-3**

Sample	Number of Schools	Average School Enrollment	% FRPL	% White	% Black	% Hispanic	% Asian	City	Suburb	Rural	Town
Population of U.S. Schools Serving K-3	55,764	440	56%	46%	15%	27%	5%	31%	32%	27%	10%
NWEA Sample: Math	7,598	455	60%	44%	17%	27%	4%	36%	31%	26%	8%
NWEA Sample: Reading	6,767	446	60%	46%	17%	26%	4%	33%	32%	27%	8%

Note: FRPL=free or reduced priced lunch. The source of the demographic variables is the Common Core of Data (CCD) collected by the National Center for Educational Statistics. The U.S. public school population comparison was determined by limiting to the schools that were operational in 2023-24 and enrolled students in kindergarten. The NWEA samples include schools that tested kindergarteners in math or reading in fall 2021.

**Table 3. Descriptive statistics by subject/grade/term**

Subject	Term	Grade	N	Mean RIT	SD RIT	Marginal Reliability	Percentage of students in each quintile					Correlation								
							Q1	Q2	Q3	Q4	Q5	KF	KS	1F	1S	2F	2S	3F	3S	
Math	F21	KF	446,344	141.88	12.36	0.93	20%	22%	18%	19%	21%	1.00								
Math	S22	KS	415,599	161.13	12.77	0.94	17%	17%	22%	27%	17%	0.73	1.00							
Math	F22	1F	346,771	159.71	12.83	0.93	17%	16%	26%	23%	18%	0.74	0.80	1.00						
Math	S23	1S	343,053	178.67	13.88	0.94	16%	18%	23%	23%	20%	0.69	0.76	0.81	1.00					
Math	F23	2F	301,767	173.13	14.94	0.95	17%	19%	22%	21%	21%	0.68	0.73	0.79	0.82	1.00				
Math	S24	2S	307,589	191.09	15.68	0.96	17%	17%	20%	27%	19%	0.65	0.72	0.76	0.81	0.83	1.00			
Math	F24	3F	273,004	184.70	14.86	0.95	15%	20%	21%	24%	20%	0.66	0.72	0.77	0.81	0.83	0.86	1.00		
Math	S25	3S	266,340	202.91	16.90	0.96	16%	16%	23%	25%	20%	0.63	0.70	0.74	0.79	0.79	0.83	0.86	1.00	
Reading	F21	KF	372,726	138.45	10.05	0.90	17%	24%	23%	18%	18%	1.00								
Reading	S22	KS	345,998	154.58	12.91	0.94	17%	21%	22%	22%	18%	0.66	1.00							
Reading	F22	1F	283,398	155.89	13.36	0.94	19%	19%	20%	21%	21%	0.67	0.79	1.00						
Reading	S23	1S	284,413	170.99	14.83	0.95	16%	20%	22%	22%	20%	0.61	0.74	0.80	1.00					
Reading	F23	2F	244,010	170.52	16.34	0.96	20%	21%	19%	19%	22%	0.57	0.68	0.75	0.80	1.00				
Reading	S24	2S	255,150	184.86	16.46	0.96	19%	18%	20%	23%	22%	0.55	0.67	0.73	0.79	0.82	1.00			
Reading	F24	3F	218,790	185.23	16.92	0.96	19%	18%	19%	23%	21%	0.53	0.65	0.71	0.77	0.81	0.86	1.00		
Reading	S25	3S	221,503	196.01	17.01	0.96	18%	16%	21%	25%	20%	0.52	0.64	0.69	0.76	0.75	0.82	0.84	1.00	

*Note.* N=number of students; SD=standard deviation; F21=Fall 2021; KF=fall of kindergarten; 3S=spring of 3<sup>rd</sup> grade. Achievement quintiles are reported based on the 2025 NWEA MAP Growth norms. Means, standard deviations, percent quintiles, and correlations were calculated based on the imputed samples.

**Table 4. Percentage of students ending up in 3rd spring quintile by initial quintile within each term**

Initial Quintile	Spring 3rd Quintile	Math								Reading							
		KF	KS	1F	1S	2F	2S	3F	3S	KF	KS	1F	1S	2F	2S	3F	3S
Q1	Q1	46.9	55.2	58.9	64.9	62.3	69.5	74.4	100.0	41.3	50.2	53.1	62.6	56.1	66.1	67.9	100.0
Q1	Q2	22.7	22.8	21.9	22.3	22.7	21.8	18.8	0.0	22.0	23.3	23.4	22.5	23.4	22.3	21.8	0.0
Q1	Q3	17.8	14.7	13.2	10.0	11.4	7.3	5.6	0.0	19.0	16.4	15.2	11.0	13.9	8.9	8.0	0.0
Q1	Q4	9.8	6.0	5.0	2.5	3.3	1.3	1.0	0.0	13.1	8.3	7.0	3.5	5.7	2.4	2.0	0.0
Q1	Q5	2.8	1.2	1.0	0.3	0.5	0.2	0.1	0.0	4.7	1.7	1.3	0.4	0.9	0.3	0.3	0.0
Q2	Q1	21.9	23.9	26.6	23.5	23.4	21.8	23.5	0.0	25.5	25.0	25.7	27.0	24.0	23.3	22.3	0.0
Q2	Q2	24.4	28.6	30.4	33.1	32.0	37.7	39.3	100.0	22.5	25.1	26.8	30.2	28.6	34.9	37.2	100.0
Q2	Q3	28.5	29.1	27.6	30.1	30.0	30.8	29.1	0.0	24.6	26.6	27.0	27.5	28.0	29.3	29.2	0.0
Q2	Q4	19.2	15.2	13.0	11.9	12.8	8.9	7.5	0.0	20.3	18.6	16.9	13.4	16.3	11.3	10.3	0.0
Q2	Q5	6.0	3.2	2.4	1.4	1.8	0.8	0.6	0.0	7.1	4.6	3.5	1.9	3.1	1.2	1.0	0.0
Q3	Q1	9.6	9.5	8.5	6.2	5.9	4.7	3.4	0.0	13.8	11.7	11.0	9.3	7.8	6.1	4.6	0.0
Q3	Q2	18.2	19.8	20.9	19.5	19.8	20.6	20.1	0.0	17.3	18.2	19.6	20.3	19.6	20.7	20.5	0.0
Q3	Q3	31.2	33.8	35.4	38.0	38.0	42.3	44.4	100.0	25.6	28.5	30.7	33.3	33.6	38.2	40.5	100.0
Q3	Q4	29.4	28.4	27.9	29.7	29.8	28.0	28.2	0.0	29.1	30.3	29.6	30.0	31.1	30.1	30.0	0.0
Q3	Q5	11.7	8.6	7.3	6.5	6.6	4.4	3.8	0.0	14.2	11.3	9.1	7.2	7.9	4.9	4.3	0.0
Q4	Q1	3.8	2.7	1.5	1.3	0.8	0.7	0.3	0.0	7.3	4.8	3.9	2.2	1.8	1.3	0.6	0.0
Q4	Q2	10.6	8.6	7.4	6.2	5.9	5.2	4.1	0.0	11.4	9.8	10.1	7.7	7.7	6.4	5.2	0.0
Q4	Q3	26.2	25.1	25.9	25.2	26.6	25.6	26.1	0.0	21.9	22.1	24.4	23.4	25.0	24.6	24.9	0.0
Q4	Q4	37.0	39.4	42.2	44.1	45.1	46.4	49.7	100.0	34.0	38.2	40.0	44.0	44.2	47.2	49.7	100.0
Q4	Q5	22.4	24.2	22.9	23.3	21.5	22.1	19.8	0.0	25.3	25.1	21.7	22.7	21.4	20.6	19.6	0.0
Q5	Q1	0.9	0.9	0.2	0.3	0.1	0.2	0.0	0.0	2.7	1.6	0.6	0.5	0.2	0.2	0.1	0.0
Q5	Q2	3.0	2.1	1.0	1.1	0.6	0.7	0.2	0.0	5.0	3.1	2.2	1.5	1.0	0.8	0.4	0.0
Q5	Q3	12.0	8.5	6.9	6.5	6.3	5.5	4.0	0.0	11.9	9.1	8.7	6.8	6.6	5.3	3.9	0.0
Q5	Q4	30.6	27.5	27.9	27.9	29.2	27.3	27.4	0.0	29.2	27.9	30.2	28.1	30.1	29.0	27.8	0.0
Q5	Q5	53.4	61.0	64.0	64.1	63.8	66.3	68.4	100.0	51.2	58.3	58.3	63.1	62.0	64.7	67.8	100.0

*Note.* Achievement quintiles are reported based on the 2025 NWEA MAP Growth norms.

**Table 5. Percentage of students proficient in grade 3 by initial quintile within each term**

Initial Quintile	Spring 3rd Proficiency	Math								Reading							
		KF	KS	1F	1S	2F	2S	3F	3S	KF	KS	1F	1S	2F	2S	3F	3S
Q1	On Track	10.3	5.6	4.7	2.1	2.8	1.0	0.8	0.0	13.9	7.2	5.8	2.5	4.5	1.6	1.4	0.0
Q2	On Track	21.0	14.7	12.1	9.9	11.0	6.7	5.7	0.0	21.7	17.4	15.0	10.5	14.0	8.1	7.1	0.0
Q3	On Track	35.3	31.0	29.1	29.6	29.6	25.5	24.9	0.0	35.9	33.6	30.4	28.4	30.0	25.5	24.5	0.0
Q4	On Track	53.2	57.3	58.3	60.4	59.3	61.1	61.4	82.4	51.8	55.3	52.8	57.3	55.6	57.3	58.2	76.4
Q5	On Track	80.4	85.5	89.2	89.3	90.3	91.2	93.5	100.0	75.4	81.9	84.0	87.4	88.0	90.0	92.5	100.0

*Note.* Achievement quintiles are reported based on the 2025 NWEA MAP Growth norms.

**Table 6. Comparison across reports of percentage of off-track K students reaching proficiency by spring of 3<sup>rd</sup> grade**

Report	Sample	Cohort	Subjects	K test	K off-track group	3rd grade outcome	proficiency flag	% of K group reaching proficiency
<b><i>This study</i></b>	<b><i>national (N=400,000)</i></b>	<b><i>K class of 2021-22</i></b>	<b><i>Math, Reading</i></b>	<b><i>MAP Growth</i></b>	<b><i>bottom quintile</i></b>	<b><i>MAP Growth</i></b>	<b><i>3rd grade proficiency cut score</i></b>	<b><i>math: 10.3%; reading: 13.9%</i></b>
<a href="#"><u>Herring et al. (2022)</u></a>	VA students (N=4,476)	K class of 2013-14	Literacy	PALS	bottom quintile			reading: 47%
<a href="#"><u>Amplify</u></a>	national (N=150,000)	K class of 2021-22	Literacy	mCLASS	at risk	mCLASS	on track	reading: 49%
<a href="#"><u>Kiguel et al. (2024)</u></a>	IL (N=170,000)	K classes of 2017-2018 & 2018-19	Math, Language & Literacy	KIDS	bottom quintile	IAR	3rd grade proficiency cut score	math: 13%; reading: 9%
<a href="#"><u>Justice et al. (2019)</u></a>	OH district (N=2,221)	K class of 2014-2015	Reading	KRA	not on track	OH ELA state test	meeting the Third Grade Reading Guarantee	reading: 33%
<a href="#"><u>Dragoset et al. (2019)</u></a>	MD (N=55,000)	K class of 2014-2015	Math, Reading	KRA	Emerging	PARCC	met expectations or above (4 or 5)	math: 11%; reading: 9%

Note. The percentage of “off-track” Kindergarten students reaching proficiency in each study are not directly comparable because the definition of off-track Kindergarten performance and 3<sup>rd</sup> grade proficiency vary by study.