Understanding Differential Growth During School Years and Summers for Students in Special Education

Angela Johnson
Elizabeth Barker

NWEA
121 NW Everett Street
Portland, OR 97209

Corresponding Author:
Angela Johnson
ORCID: 0000-0003-4114-2446
angela.johnson@nwea.org
(909) 969-0657

Understanding Differential Growth During School Years and Summers for Students in Special Education

Abstract:
Under the Individuals with Disabilities Education Act, schools are required to provide a free and appropriate public education to students with disabilities and show that the students are making academic progress. This study compares within- and across-years academic growth from kindergarten to 4th grade for students who were ever in special education (ever-SPED) to students who were never in special education (never-SPED). We use math and reading assessment scores from NWEA's Growth Research Database. Our dataset contains one cohort of about 4,200 students, assessed up to three times per year for five years. Although ever-SPED students started kindergarten with lower math and reading test scores and grew less in both subjects than never-SPED students during the kindergarten school year, ever-SPED students grew more than never-SPED students during the 1st and 2nd grade school years in math and 1st, 3rd, and 4th grade school years in reading. However, ever-SPED students lost more learning during every summer than never-SPED students. This led the test score disparities between the two to grow from under 0.5 standard deviations in kindergarten to 1.0 standard deviation in 4th grade. These findings suggest that summer learning opportunities are crucial for improving educational outcomes for students with disabilities.

Under the Individuals with Disabilities Education Act (IDEA, 2004), students with disabilities obtained the right to a free and appropriate public education provided in the least restrictive environment (Jacob et al., 2016), evidenced by gains in academic skills (Tatgenhorst et al., 2014). As a result, schools are under legislative and social imperatives for educating students with disabilities. However, data showing equitable outcomes for this vulnerable student population are scant.

Cross-sectional data tended to suggest large opportunity disparities between students with and without disabilities (e.g., National Assessment of Education Progress, 2019). Despite the emphasis legislations placed on academic progress for students with disabilities, only a handful of studies to date have examined this important topic (Francis et al., 1996; Morgan et al., 2011; Wei et al., 2011, 2012). The shared limitation among these studies is that achievement data were collected only about once a year. As a result, research is unable to quantify within-year growth in achievement or summer learning (loss) for students with disabilities.

Learning and loss during summers and out-of-school time is especially important to students with disabilities. Free and appropriate public education requires that schools provide instruction that is “appropriately ambitious” and show the student is making progress (U.S. Department of Education, Questions and Answers, 2017). To demonstrate this, schools typically assess and report students’ progress towards their annual goals (Sabia et al., 2020). As a result, measuring within-year academic growth is critically important in determining whether students are receiving a free and appropriate public education. For example, a flat fall-to-spring achievement trajectory— an indication for lack of progress—would suggest that students are not getting a free and appropriate public education. In addition, the regression-recoupment standard is one of the central factors used to determine qualification for extended school year services, making summer learning (loss) an important measure for program eligibility.

The current study compares within- and across-years academic growth from kindergarten to 4th grade for students ever in special education to students never in special education. We use a unique data set from the NWEA Growth Research Database, which contains one cohort of students who were assessed up to three times per year for five years. Our research questions address differences in achievement levels and growth between students who were ever in special education ("ever-SPED") during kindergarten to 4th grade and those students who were never in SPED services ("never-SPED"):

1. How does mean achievement level in each grade compare between ever-SPED and never-SPED students?
2. How does achievement growth during each school year and summer between kindergarten and 4th grade compare between ever-SPED and never-SPED students?

This is the first study to compare within-year growth rates of students with and without disabilities. We examine academic growth separately for when school is in versus out of session, which is referred to as seasonal learning in prior literature (e.g., von Hippel & Hamrock, 2019). Previous studies have explored seasonal learning patterns and shown sizeable disparities in academic growth rates by student and school characteristics (e.g., Kuhfeld et al., 2020; von Hippel et al., 2018), but whether findings generalize to students in special education is unknown. Our study features the most comprehensive seasonal analysis of special education to date and addresses a critical gap in the research.

Educational Services for Students with Disabilities

Federal Legislations

In 2002, the No Child Left Behind federal legislation was passed and required schools to support all students, including those with disabilities, to reach proficiency in reading and math achievement. Additionally, in the 2003 reauthorization of IDEA, the accountability provisions further aligned with No Child Left Behind, which included but was not limited to: (a) measuring annual yearly progress; (b) determining measurable annual objectives; (c) linking assessments under Title I to the use of appropriate accommodations on individual education programs (IEPs) to ensure student achievement;; and (d) providing prereferral intervention for preventing early reading failure (No Child Left Behind, 2002; Rosenberg et al., 2004). More recently, the Every Student Succeeds Act (2015) maintains the requirements that ensure the inclusion of students with disabilities in accountability systems. Additionally, the Every Student Succeeds Act supports state-designed general and alternative assessment systems that accurately measure students with disabilities through accommodations and incorporating principles of universal design for learning (National Council on Disability, 2018).

Free and appropriate public education plays an important role in the education of students who are eligible for services under IDEA and Section 504. IDEA makes a free and appropriate public education available to students with a disability nationwide and entitles students to special education (SPED) and related services. Under Section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C § 794 (Section 504), free and appropriate public education requires that schools support (a) students with disabilities who qualify for SPED and (b) students who are in general education and in need of related aids and services as adequately as students without disabilities (Office for Civil Rights, 2020).

SPED Placement and Services

To comply with federal law, schools must provide specially-designed instruction at no cost to meet the needs for students with disabilities. Schools must follow the steps laid out within IDEA, which include but are not limited to: Child Find, eligibility, IEPs, goals and objectives, and placement. Child Find requires schools to have a process for identifying and evaluating students who may need SPED and related services (IDEA, Sec. 300.111). A student qualifies for SPED when they meet a certain specification in the eligibility analysis. The student must meet the one of the following 13 definitions under IDEA,[1] and it must be determined that the disability has an impact on the student's academics. This is shown through an evaluation process not only with diagnostic testing, but also with classroom academic performance and observation.[2] In 2018-19, 7.1 million students, or 14% of the total student population, received SPED services under IDEA (National Center for Education Statistics, 2020). About 10% of students receiving SPED services additionally qualify for English Learner (EL) services because they are developing English proficiency (U. S. Department of Education, 2021).

SPED services move beyond access to materials and curriculum. The goal of SPED is to deliver instruction that is unique and personal to each student with a disability. Placement determines how services are delivered to specifically address the student's IEP goals and objectives. These goals and objectives are reviewed annually and should be updated based on student progress. Recently, the Supreme Court ruled in *Endrew F. v. Douglas County* (2017) that the ability to show student progress is an essential aspect of a free and appropriate public education.

Extended School Year Programming

Another aspect to a free and appropriate public education that is unique to students who qualify under IDEA is extended school year programming, which go beyond the typical school year. Programs can provide academic content such as reading and mathematics and can include additional services such as speech language or behavioral therapy. Students are recommended for service based on an individual basis (Tatgenhorst et al., 2014). Local education agencies must provide extended school year programs to a student who qualifies for SPED when the service is deemed necessary.

There is limited information about how local education agencies determine extended school year eligibility (Barnard-Bark & Stevens, 2020), and determination of the appropriateness of extended school year can vary. For example, the 5^{th} and 10^{th} Circuit Courts concluded that extended school year services are appropriate when the gains a student with a disability has made during the school year are significantly jeopardized if they are not provided with extended school year during the summer months (e.g., *Alamo Heights Independent School District v. State Board of Education*, 1986). The 6^{th} Circuit, in contrast, determined that extended school year services are appropriate when they prevent significant regression of skills or knowledge that would seriously affect the students' progress toward self-sufficiency (Tatgenhorst et al., 2014). Extended school year has typically been seen as necessary when an interruption in a student's education during the summer months or lack thereof hinders the gains a student made during the school year (e.g., *Jackson Johnson v. District of Columbia*, 2012). This particular loss of learning gains is referred to as the regression-recoupment standard and is used as one potential factor to qualify students for extended school year (Queenan, 2015). Regression-recoupment is typically described to SPED teachers as the amount of time it takes a student to regain in the fall what they have lost over the summer months. How local agencies actually determine this regression is difficult to identify and seems to vary (Barnard-Brak & Stevens, 2020), though nearly every state uses some form of regression-recoupment standard as one of the factors for extended school year services (Queenan, 2015).

Academic Outcomes for Students with and Without Disabilities

Cross-sectional data indicate that students with disabilities have lower test scores than students without disabilities. For instance, in 2019, the average 4th grade National Assessment of Educational Progress math score was 245 for students without a disability and 214 for students with a disability with allowable accommodation; in 8^{th} grade, the average math scores were 287 and 247, respectively. In reading, the contrast was 226 versus 184 for 4^{th} grade and 268 versus 229 for 8^{th} grade (National Assessment of Educational Progress, 2019). Studies of math and reading achievement, many of which statistically controlled for students' demographic and socioeconomic characteristics, tended to report large gaps between students with and without disabilities. In a recent meta-analysis that included 180 effect sizes from 23 studies on reading achievement, Gilmour et al. (2019) found that students with disabilities scored 1.17 standard deviations below their peers without disabilities. Students with disabilities who are developing English proficiency, sometimes referred in the literature as EL and SPED dually-identified students, face even more severe disparities in academic outcomes compared to students with disabilities who are native or fluent users of English and students without disabilities (Lazarus et al., 2016; Solari et al., 2014; Stevens, 2018).

In contrast to these studies, which focused on a static outcome measured at one or two points in time, another line of inquiry used multilevel modeling to explore the relation between disability and within-student academic growth. Francis et al. (1996) used data from the

Connecticut Longitudinal Study and found that the reading growth trajectories of children with reading disabilities were better characterized by a deficit (i.e., students with lower initial reading level also grew slower over time) rather than a lag (i.e., students with lower initial reading level grew faster and caught up over time) model. Morgan et al. (2011) tested the same theories using math and reading achievement data from Early Childhood Longitudinal Study – Kindergarten Cohort. Morgan et al. (2011) found that children with learning disabilities or speech language impairments had significantly lower levels of kindergarten achievement than children without disabilities, but their growth trajectories between kindergarten and 5th grade differed by disability category. Also leveraging data from Early Childhood Longitudinal Study –Kindergarten Cohort, Kohli et al. (2015) compared the growth rates in math achievement for students with learning disabilities to students without disabilities. They found that students with learning disabilities progressed at a lower rate than students without disabilities. Using nationally-representative data from the Special Education Elementary Longitudinal Study, Wei et al. (2011) and Wei et al. (2012) examined academic trajectories for students with disabilities ages 7 to 17 and found that achievement levels varied by disability category, while growth rates were comparable across categories. Similar to Francis et al. (1996), Wei et al. (2011) found that in reading, students with disabilities who started with lower initial scores also grew slower, resulting in an expansion of gaps over time. In math, students with disabilities also grew slower than the national norming sample in elementary school (Wei et al., 2012). Stevens and Schulte (2017) used data from students in North Carolina and found that students with learning disabilities had lower achievement and lower growth rates from grades 3 to 7 than students without disabilities. Leveraging a similar data set, Stevens et al. (2015) showed that students in all groups had significant growth that decelerated over grades, and the large achievement disparities between students with and without disabilities remained relatively stable over grades. Tindal and Anderson (2019) examined data for students who took the Oregon Assessment of Knowledge and Skills and found results similar to the two North Carolina studies: students with learning disabilities grew over time, but not enough to reduce the difference between themselves and students without disabilities.

These studies were able to leverage vertically-scaled measures to estimate within-student growth. However, they share an important limitation: since assessment data were collected only once a year (e.g., Stevens & Schulte, 2017) or once every couple of years (e.g., Kohli et al., 2015; Morgan et al., 2011), growth could only be estimated across years but not within year. One study (Hurwitz et al., 2020) used MAP Growth data, collected multiple times a year, and improved upon these previous studies. Hurwitz et al. (2020) followed a sample of 575 students from a large, urban district as they transitioned between general and special education. Using a multilevel student fixed-effects model, they found a significant, positive relation between SPED and achievement trajectories in both math and reading. That is, academic growth was stronger after entering SPED compared to prior semesters, and substantial growth continued even after students exited a SPED program, suggesting that services had a lasting positive influence. By coding the unit of time as semester rather than year, this study provided richer within-year data than previous research. However, it does not address the important question on seasonal patterns of learning.

Seasonal Learning Patterns

Only one study of which we are aware examined summer learning for students with IEPs (Gershenson and Hayes, 2017). This study estimated learning rates in the summer between kindergarten and 1st grade using data from Early Childhood Longitudinal Study – Kindergarten

Cohort. Gershenson and Hayes (2017) found that students with IEPs had slightly higher summer learning rates than mainstream students, but the difference was not statistically significant. They also reported that students with IEPs were more likely to enroll in summer school and less likely to participate in organized summer activities than their mainstream counterparts. This study offered evidence for differences in summer learning, but the analysis was limited to the summer after kindergarten and only included 50 students with IEPs. To our best knowledge, no study has looked at summers between higher grades.

Research is needed to unpack how disparities in achievement between students with and without disabilities may develop during the school year versus summer break. A body of research using datasets comprised mostly of students without disabilities has highlighted seasonal patterns of learning, with gains during the school year followed by flattening or dropping of test scores over the course of summer breaks (e.g., von Hippel & Hamrock, 2019). Additionally, average growth rates have been found to decelerate across school years (Bloom et al., 2008; Thum & Hauser, 2015), which means that estimating a single overall school-year growth rate will mask systematic differences in learning rates across grade levels. However, these studies did not distinguish between students with and without disabilities or between students in general education and SPED programs. By estimating within-student growth and examining seasonal patterns of learning for students by SPED participation, this study addresses a critical gap in the research.

Methods

Data Sources

The data for this study come from the NWEA Growth Research Database. NWEA is a research-based, not-for-profit organization that partners with schools across the nation and provides assessments that measure student academic growth and proficiency. School districts choose to administer NWEA's MAP Growth assessments for a variety of purposes, including monitoring student achievement and growth, staff evaluation, and school accountability. Through a rostering process, NWEA collects students' demographic data (e.g., gender, race/ethnicity) from schools that administer the assessments. These school-reported data, as well as students' assessment scores, are included in the Growth Research Database. The database covers more than 20% of the K-12 student population but are not nationally representative. While the database includes private and international schools, we focus only on U.S. public schools in this study.

Districts that administer MAP Growth assessments voluntarily report students' gender and race/ethnicity and can choose to also identify students in SPED services. Since reporting SPED data is optional, only a subset of districts provided complete data in these fields.[3] Having verified the number of students in SPED services in the district against the National Center for Education Statistics (NCES) Common Core of Data (CCD), we restrict our analysis to districts that provided complete data.[4]

Sample

A school is included in the sample if it is in a district that tested any ever-SPED student and reported complete data on SPED services. Appendix Table A1 presents a comparison of summary statistics of the 109 schools in this study to all public schools serving kindergarten in the CCD (total=55,824; sample = 0.20% of total). Compared to all public schools, schools in the sample were less likely to be urban, more likely to be rural, and served higher percentages of White students and students eligible for free or reduced-price lunch (FRPL) and lower percentages of students of color.

The sample includes 4,228 ever-SPED (N=786) and never-SPED (N=3,442) students who attended kindergarten and took at least one MAP Growth assessment in 2014-15. This kindergarten cohort is observed in the dataset for five years to 2018-19, or the end of their 4th grade. Table 1 shows summary statistics for students in the sample. Demographics for students who took the MAP Growth math assessments are very similar to students who took the reading assessments because most students were assessed in both subjects. The math sample is 49% female, 2% Asian, 9% Black, 23% Hispanic, and 42% White.

Students in SPED service during at least one year between kindergarten and 4th grade are categorized as "ever-SPED" in the data regardless of the duration and timing of SPED service. The timing of identification and services during the early grades can vary based on the school's or the district's practices. We therefore use ever-SPED as a proxy for students with disabilities who require SPED services. Of the ever-SPED group (N=786), 36% of the students were first placed in SPED services in kindergarten, 28% in 1st grade, 18% in 2nd grade, and 18% in 3rd or 4th grade. Ever-SPED students comprised 19% of the sample of 4,228 students and were less likely to be female or students of color compared to the 3,442 never-SPED students. About 21% of ever-SPED students were consistently in SPED services during every term in which they were assessed ("always-SPED"). We follow previous research (e.g., Tindal & Anderson, 2019) and report achievement and growth separately for this group. Students who were additionally in EL services at any time between grades K-4 comprised 22% of the ever-SPED students ("EL-SPED"). This doubly-vulnerable student group has been shown to face even larger disparities in academic opportunities than students with disabilities but with no need for language support (Solari et al., 2014; Stevens, 2018). We thus report results for this subgroup separately.

Students were assessed during a maximum of 15 terms (fall, winter, and spring) over five years. Due to differences in assessment policies across states and districts, as well as student attrition, not all students were assessed during all 15 terms. Appendix Table A2 shows the number of students assessed at each term and the total number of terms students were assessed. About 74% of all students and about 85% of ever-SPED students were assessed for eight or more terms. As described in the Analysis section, we include all students in the kindergarten cohort in the main analyses regardless of attrition. As a sensitivity check, we repeat the analyses for the subsample of students who were assessed in eight or more terms. Results are similar to the full sample and reported in Appendix Table A4.

[Table 1 here]

Measures of Achievement

Students were tested using the MAP Growth math and reading assessments up to three times (fall, winter, and spring) during each school year. MAP Growth assessments are computerized, adaptive tests aligned to state content standards. Measurement is precise even for students above or below grade level. In the early grades, MAP Growth includes developmentally-appropriate items, interactive elements, and audio supports to engage and accurately assess early learners. Each test takes approximately 40 to 60 minutes to administer. Achievement scores are reported on the Rasch unit (RIT) scale, where RIT is a linear transformation of the logit scale units of the Rasch item response theory model. Test scores are vertically scaled to allow estimation of growth within and across years. [5]

Analysis

Research Question 1. *How does mean achievement level in each grade compare between ever-SPED and never-SPED students?*

We plot and report the mean achievement scores in the fall, winter, and spring of each grade for ever-SPED, always-SPED, EL-SPED, and never-SPED students. The plot also shows the national mean from the NWEA achievement norms for comparison (Thum & Kuhfeld, 2020).

Research Question 2. *How does achievement growth during each school year and summer between kindergarten and 4th grade compare between ever-SPED and never-SPED students?*

To estimate academic growth, we use a piecewise random-intercept model and apply it separately to ever-SPED, always-SPED, EL-SPED, and never-SPED students. One important advantage of the piecewise multilevel model is its ability to account for variation in test administration dates within the school year and allow for separate growth terms in each school year and summer (e.g., Quinn et al., 2016). Therefore, we can look at whether any differences in growth rates between student groups expand, stay the same, or diminish across grade levels.

The model accounts for variations in test dates and estimates growth as a linear function of students' exposure to each school year and summer. Students were not tested on the first and last days of school each year; even within school, students' test dates varied depending on factors like the availability of electronic devices used for testing. Therefore, exposure to instruction varied. We calculate months of exposure based on school start and end dates and the test administration dates (see Appendix B for details). For example, a student testing at the end of August in 1st grade may have 9.7 months of exposure to kindergarten, 2.3 months of exposure to the summer following kindergarten, and one week of exposure to 1st grade.

At level 1, we model achievement conditional on exposure to school during the academic year for each grade level (e.g., G0 = kindergarten academic year) and exposure to summer after each grade level (e.g., S0 = summer after kindergarten).

Level 1 (time (*t*) within student (*i*)):

$$y_{ti} = \beta_{0i} + \beta_{1i}G0_{ti} + \beta_{2i}S0_{ti} + \beta_{3i}G1_{ti} + \beta_{4i}S1_{ti} + \beta_{5i}G2_{ti} + \beta_{6i}S2_{ti} + \beta_{7i}G3_{ti} + \beta_{8i}S3_{ti} + \beta_{9i}G4_{ti} + r_{ti} \quad (1)$$

The model "implicitly extrapolates beyond the test dates to the scores that would have been achieved on the first and last day of the school year" (von Hippel et al., 2018, p. 335). The intercept (β_{0i}) is the predicted score for student *i* testing on the first day of kindergarten, regardless of how many instructional days elapsed. The slopes ($\beta_{1i}, \ldots, \beta_{9i}$) are the monthly learning rates of student *i* during each school year and summer. Each test score y_{ti} is viewed as a linear function of the number of months that student *i* has been exposed to kindergarten ($G0_{ti}$), 1st grade ($G1_{ti}$), etc., through 4th grade ($G4_{ti}$); and the number of months that the student has been exposed to the summers after kindergarten ($S0_{ti}$) through 3rd grade ($S3_{ti}$).

At level 2, a random intercept is included to allow students' starting achievement in fall of kindergarten to vary by student; slopes are treated as fixed. Models are estimated using HLM 8.0 software (Raudenbush et al., 2019).

Level 2 (student (*i*)): (2)

$$\beta_{0i} = \gamma_{00} + u_{0i}$$

$$\beta_{1i} = \gamma_{10}$$

$$\vdots$$

$$\beta_{9i} = \gamma_{90}$$

Variance component specification:

$$r_{ti} \sim \mathrm{N}(0, \sigma^2), \; u_{0i} \sim \mathrm{N}(0, \tau_{00}).$$

Results

Research Question 1. *How does mean achievement level in each grade compare between ever-SPED and never-SPED students?*

Figure 1 shows mean math and reading achievement at each grade and term (fall, winter, spring). The corresponding means are reported in Appendix Table A3. In both math and reading, ever-SPED students entered kindergarten with considerably lower test scores than never-SPED students (difference = 4.8 RIT or 0.50 standard deviations (SD) in math; 4.0 RIT or 0.43 SD in reading).[6] Never-SPED students in the sample scored consistently above the national mean during each term from kindergarten to 4th grade. Ever-SPED students scored just above the national mean in the fall of kindergarten but fell behind during kindergarten. The difference between ever-SPED and never-SPED students expanded between kindergarten and 4th grade (end difference = 13.9 RIT or 1.02 SD in math; 14.2 RIT or 1.04 SD in reading), with larger summer drops for ever-SPED students. Achievement scores for always-SPED and EL-SPED students were similar to the ever-SPED average, except spring test scores tended to be slightly lower for these two subgroups.

[Figure 1 here]

Research Question 2. *How does achievement growth during each school year and summer between kindergarten and 4th grade compare between ever-SPED and never-SPED students?*

Figure 2 shows model-estimated monthly growth rates (in RIT points) in math and reading during each grade and summer and the estimates' 95% confidence intervals. The corresponding estimates and standard errors are reported in Table 2. Estimates for the always-SPED and EL-SPED subgroups are less precise and their confidence intervals larger due to the smaller subsample sizes. Thus, we focus below on the growth rate contrast between the pooled ever-SPED group and the never-SPED group. During the kindergarten school year, ever-SPED students tended to grow less than never-SPED students in math (1.95 RIT versus 2.18 RIT per month) and reading (1.76 RIT versus 2.03 RIT per month). In math, ever-SPED students grew more than never-SPED students during 1st and 2nd grade and slightly less during 3rd and 4th grade. In reading, ever-SPED students grew more than never-SPED students during 1st, 3rd, and 4th grade. During the summers, however, ever-SPED students lost more learning than never-SPED students in math and reading, as depicted by the longer negative bars in the bottom panel. For instance, in the summer after kindergarten, ever-SPED students lost 1.20 RIT per month in math while never-SPED students lost 0.70 RIT per month; in reading, ever-SPED students lost 1.28 RIT while never-SPED students lost 0.41 RIT per month. This means that over the course of a 2.75-month summer between kindergarten and 1st grade, the achievement disparity between ever-SPED and never-SPED students expanded by about 0.1 SD in math and 0.2 SD in reading. Similarly, ever-SPED students lost more learning than never-SPED students in the summers after 1st, 2nd, and 3rd grade. Cumulatively, the larger learning loss happening during summers offset the greater progress ever-SPED students made over the academic years, resulting in an expansion of disparities in the long run.

[Figure 2 here]

[Table 2 here]

Discussion

This is the first study to investigate seasonal learning patterns across multiple grades for students in special education. We used a dataset for one cohort of students that contained assessment scores from kindergarten to 4th grade and examined growth separately in each school year and summer for students ever in SPED services and students never in SPED services. We report three main findings. First, ever-SPED students entered kindergarten with lower test scores than never-SPED students and grew less during the kindergarten school year. Second, between grades 1 and 4, ever-SPED students grew more than never-SPED students during some of the school years. Third, summer learning loss was greater for ever-SPED than never-SPED students. These differential growth patterns contributed to expanding disparities between the two groups from less than 0.4 SD in the fall of kindergarten to about 0.9 SD at the end of 4th grade.

Disparities at Kindergarten Entry

In both reading and mathematics, we found large disparities in kindergarten fall test scores between ever-SPED and never-SPED students. This echoes the results in Tindal & Anderson (2019) and Stevens & Schulte (2017) and suggests there may be a need for better early childhood education opportunities for students with disabilities. These initial gaps might be addressed with earlier identification of students' special needs and provision of appropriate pre-kindergarten education and support services. A developing line of inquiry (e.g., Schochet et al., 2020) investigates the effects of various early childhood education programs on the outcomes of students with disabilities measured in kindergarten. Our data do not include information about early childhood education and support for students with disabilities, so we were unable to identify associations between early identification and intervention and later academic growth. Future research should inform how policy and programming can provide earlier interventions to better prepare students with disabilities for kindergarten.

K-4 Growth Patterns

Adding to existing studies (e.g., Morgan et al., 2011; Stevens & Schulte, 2017; Tindal & Anderson; 2019), we provide more evidence that the achievement disparities that already existed in kindergarten expand through 4th grade. Previous studies interpreted this pattern as reflecting a

Matthew effect (Duff et al., 2013; Morgan et al., 2011; Stanovich 1986, 2000), or the notion that advantages and disadvantages accumulate, and with time the students with higher initial proficiency gain more while students with lower initial proficiency gain less. For example, Stanovich (1986) argued that individual differences in reading could accumulate over time, contributing to a widening gap in reading achievement. Our research interrogated this theory by diving into seasonal growth patterns, and we found the observed long-term *Matthew effect* to be a cumulative result of some school-year, but mostly summer growth rate disparities.

Ever-SPED students grew less than their never-SPED peers in both math and reading during the kindergarten school year. This may suggest a need for better identification of students who are struggling and better support as students transition into school. In our data, 64% of students in the ever-SPED group were not placed in SPED in kindergarten but were placed in later grades. Though we cannot say with certainty that it was delayed placement or lack of service that led to the lower growth rates, we cannot rule out this possibility. Since we do not observe identification date or intervention and service types, we were not able to investigate the links among identification date, support received during kindergarten, and academic growth. We encourage future studies to take up this important topic. However, extant research provided evidence supporting early identification and service implementation (Gersten et al., 2005; Oslund et al., 2012; Wanzek et al., 2018). When considering classroom frameworks for instruction, kindergarten is not too early for implementations of structures such as universal design for learning, response to intervention or multi-tiered system of supports. In fact, holistic approaches with itinerate specialists such as, but not limited to, speech language pathologists, learning specialists, or behavioral specialists may be the support students need. These types of frameworks also encourage early intervention, with the philosophy that students who are not yet identified should receive support. Additionally, research has shown that providing access to materials with explicit, direct instruction in reading and mathematics improves academic success for students who are struggling (Clements et al., 2017; Kim & Quinn, 2013).

During subsequent school years, ever-SPED students showed they were capable of growing *more* than or as much as never-SPED students (during two grade levels in math and three grade levels in reading). This novel evidence challenges deficit narratives around the academic potential of students with disabilities and highlights the importance of examining growth separately for each grade and summer. Other studies using annual assessment data have investigated growth rates for students with various disabilities and have found slower growth rates when compared to students without disabilities (Stevens & Schulte, 2017; Wei et al., 2012). In our study, too, estimating one growth trajectory across K-4 would have led to the oversimplified conclusion that ever-SPED students grew less than their never-SPED peers. But our seasonal learning analysis revealed more nuance: with appropriate support, students with disabilities can grow more than or as much as students without disabilities (shown in our data during half of the early grades). This is consistent with Hurwitz et al. (2020), who found that receiving SPED services is associated with higher rates of within-year academic progress. The key is identifying features of programs and services that work well for specific groups of students with disabilities and suitable points of intervention. For instance, Schwartz et al. (2021) found SPED programs to be beneficial specifically to students with learning disabilities. More research that follows this line of inquiry might examine what types of services are especially effective for supporting math/reading development for students in different disability categories and more specifically, during which grades.

Summer Learning

Despite comparable or even faster growth rates during the school year, much larger summer losses for ever-SPED students (-1.2 to -2.1 RITs per month, compared to -0.4 to -0.8 RITs for never-SPED) accumulated to shape the expanding gaps between the two student groups. This is in contrast to Gershenson and Hayes (2017), who found that in the summer between kindergarten and 1st grade, learning rates for students with IEPs and mainstream students were statistically similar. The differences between the findings of these two studies may lie in the two distinct samples (Gershenson and Hayes (2017) only included 50 students with IEPs.). Previous research on students with disabilities has not addressed seasonal patterns across multiple grades with a large sample. Our findings draw attention to learning opportunities during the summer months, in which support services are unavailable to many students with disabilities.

Gershenson and Hayes (2017) found that in the summer between kindergarten and 1st grade, students with IEPs were more likely to attend summer school and less likely to participate in organized summer activities than their mainstream counterparts. In this study, we did not have access to extended school year or summer program participation data and could not examine participation in relation to summer learning rates. This is an area that requires further investigation. To understand who is receiving summer services and whether those services are beneficial is crucial to policy decisions. For example, some students with disabilities may be attending school summer programs (e.g., summer reading programs), but their participation may not be indicated in their IEPs as extended school year services (Barnard-Bark & Stevens, 2021). Without accounting for program type and student participation, schools have only incomplete data to make high-stakes decisions about students' progress and ongoing service eligibility. Thus, tracking program participation in tandem with academic achievement is critical to ensuring students with disabilities are receiving a free appropriate public education.

Previous literature suggests that extended school year programs may be beneficial to students with disabilities. For instance, Barnard-Brak & Stevens (2021) found that approximately 8% of students with disabilities received extended school year services, and that these services appear to be a proactive way for schools to minimize the loss of achievement and possible effective way to use public funds. However, one of the top barriers to extended school year is difficulty in determining eligibility (Barnard-Brak et al., 2018). Currently, 73% of local educational agencies are using regression recoupment models as one criterion to determine eligibility for ESY services (Barnard-Brak & Stevens, 2021). However, there is no standard model or system of measuring regression-recoupment. Our study points to the potential of using disaggregated data (e.g., spring-to-fall changes in achievement level) to investigate the needs of vulnerable student populations, including students with disabilities. With nearly every state using some form of regression-recoupment standard for determining extended school year service eligibility (Queenan, 2015), further research should be conducted to explore the implementation and effects of these policies.

Beyond recoupment of learning loss, there is an urgent need for both funding and rigorous research on summer programming for students with disabilities. There are very few studies on the expenditure and efficacy of summer learning programs for students with disabilities. Case studies based on a handful of programs tended to highlight the high cost of such programs (McCombs et al., 2011; Reed et al., 2019; Reed, et al., 2020). Though frequently cited, these findings must be interpreted with caution because they can lack generalizability due to the small sample sizes. More financial support for research and program development will provide schools with knowledge of evidence-based practices. Federal, state, and local policymakers should prioritize investment in developing high-quality summer programming for students with disabilities in policy, especially in funding decisions.

Limitations

A few limitations merit consideration when interpreting the results of this study. First, our sample included schools that provided complete data on student-level SPED program information[7], which are likely to be more motivated to serve students with disabilities than the average school. Our sample is therefore not representative of the national population of schools or students, and the achievement disparities may be underestimated. Second, our findings are descriptive: the estimated differences in achievement level and growth rates do not represent causal links. Third, the size of our sample does not support analyses by gender or racial/ethnic subgroup, and our estimates for the EL-SPED group were imprecise. Fourth, we do not have students' date of identification or detailed information about services; as a result, we cannot account for heterogeneity in the amount, type, or quality of services students received. Some students may have been identified before kindergarten and receiving appropriate services that met their needs; others may have experienced delays in identification and/or inadequate service. Additionally, we do not have access to students' disability categories, therefore, we were not able to address variations by disability. In light of these limitations, we urge future research to study variations within the population of students with disabilities with disaggregated data.

Future Directions

We hope this study will catalyze more research on the academic and nonacademic progress of children with disabilities. Research should continue to seek robust evidence on correlational and causal relations between school and social factors and academic and socioemotional outcomes for students with disabilities. We encourage future studies to investigate the links between summer program or extended school year participation and student achievement and growth. Disaggregating data by disability type will provide insights that are especially important (Boroson et al., 2017). For example, a better understanding the rate of recoupment based on disability type could help inform extended school year programs. In addition, scholarly attention should focus on students who are doubly vulnerable, such as students of color with disabilities and students with disabilities who are developing multilingual proficiencies.

Another key area for future development is assessment. Most existing tests for measuring academic achievement were designed for students without disabilities, and relatively little is understood about how students with disabilities experience and perform on these assessments. For example, there is no study on test engagement for students with disabilities, while research on test engagement for students in general education has been developing for decades (e.g., Wise et al, 2009). Students' engagement and experience with testing directly impact not only their performance but also the validity of their scores and in turn, the programming and policy decisions made based on those test scores. Future research should focus on developing assessments that support inferences for the achievement and progress of students with disabilities. Providing more accurate assessments will move research toward centering our understanding of growth and achievement on students with various disabilities (e.g., students with learning disabilities, deaf and hard of hearing, visual impairments) rather than relying on or reinforcing ableist perspectives.

Concluding Remarks

At the heart of IDEA is providing a free and appropriate public education, which ensures the educational needs of students with disabilities are recognized and addressed. The law has specific requirements to meet the unique needs of students with disabilities to prepare those students for college, career, and independent living. To date, research on the effectiveness of these statutes on student outcomes is limited. With nearly seven million students eligible for special education across the U.S., it is imperative we understand how students with disabilities are performing and that we continuously strive for better student outcomes. This study provides an essential piece of new evidence on seasonal learning and within-year growth for students with disabilities, but there is still much to learn.

Our findings suggest that more support is needed for students with disabilities in the transition to kindergarten: students with disabilities are growing less during their kindergarten year than students without disabilities in both reading and math. Kindergarten is a pivotal year to make growth gains. Although opportunities to learn before kindergarten vary by family income, race/ethnicity, and other factors, research shows that, on average, students grow most during kindergarten, and growth slows down during subsequent grades (Clements et al., 2017; Kuhfeld, et al., 2019; Levine et al., 2010). In this study, however, ever-SPED students grew less in kindergarten than they did in 1st grade. This points to potential missed opportunities to learn during the kindergarten year. As a result, it may be beneficial to start sooner with identification of struggling students and academic inventions. Research can help guide the provision of services in the transition to kindergarten. More attention needs to be given to early learning and services that support it. For instance, future research should investigate the effects of early identification and special education services for students with disabilities aged 0 to 5.

What is more striking about our results is that ever-SPED students showed they are capable of more growth than never-SPED students in subsequent grades. However, these gains seem to be lost during the summer months when most schools are on break. This calls for more research to address extended school year services and the potential impact of increasing access to learning activities over the summer. Taken collectively, the findings of this study strongly suggest further investigation for seasonal learning and early identification.

Even more pressing, our results beg the question about how students with disabilities fared through the unprecedented event of the COVID-19 pandemic. We anticipate uneven impacts and differential unfinished learning, especially for students with disabilities, for various reasons. During the pandemic, some students received instruction online, some in hybrid models, and others received no instruction for months (Stelitano et al., 2021). Students with disabilities often require small-group or one-on-one support from the teaching staff, which can be difficult to deliver or less effective when provided remotely. If loss of opportunities to learn during the pandemic is similar to loss of learning opportunities during summer break, then the findings of this study provide further reason to believe that students with disabilities would be more severely impacted than their peers as a result of the pandemic. As schools and students continue to recuperate, there is an urgent need to gauge and respond to the impacts the pandemic has had on student learning, especially for students with disabilities, who are likely to be more affected by loss of learning opportunities during out-of-school time.

Lastly, we need to use data to inform policy and services. Our study is a launching point for investigating seasonal patterns and post-pandemic learning for vulnerable student groups. Within the population of students with disabilities, it is imperative to disaggregate data for subgroups with distinct needs, such as students of color, English learners with disabilities, and students with multiple disabilities. Doing so will help pinpoint the areas of need, so schools and districts can make targeted changes to improve policy and practices.

Notes

[1] The 13 categories are: (a) autism; (b) deaf-blindness; (c) deafness; (d) emotional disturbance; (e) hearing impairments; (f) intellectual disability; (g) multiple disabilities; (h) orthopedic; (i) other health impairments; (j) specific learning disability; (k) speech or language impairment; (l) traumatic brain injury; (m) visual impairment including blindness (34 CFR 300.8(a)(1)). Because some disabilities are difficult to diagnose, states may choose to designate a student as "developmentally delayed"; however, there is typically a timeline for this particular designation, and students may then transition out of SPED or into one of the 13 aforementioned categories.
[2] If a student's disability does not impact their academics, the student will not qualify for SPED. However, they could still receive services and protections under Section 504 Rehabilitation Act of 1973.
[3] We determine whether a district submitted complete SPED program data by comparing the total number of students in SPED services reported for each district in the GRD to the CCD (NCES, 2017). For about 8% of districts in the GRD, the numbers of students in SPED reported to GRD and CCD were within 20% of each other; for about 4% of districts, the two numbers were within 10% of each other.
[4] We examine the quality of the service eligibility indicators in our data in two ways. First, we compare the total number of students in SPED services reported for each district in the GRD to the CCD. We retain districts for which the reported number of students in SPED from the two data sources were within 10% of each other. Second, we examine the data files, which contain binary indicators for service eligibility as well as text fields for classification results or program participation. In this qualitative check, we verify that the text fields provided descriptions that were relevant to SPED services. For instance, many of the SPED text field values included disability categories or classification notes.
[5] Average test duration, standard error of measurement, and percentage of rapidly-guessed items (items to which students responded in a very short amount of time, insufficient to read/comprehend the item) were similar for ever-SPED and never-SPED students.
[6] For comparison, estimated Black-White achievement disparities in math and reading are 0.54 SD and 0.41 SD, respectively (Kuhfeld et al., 2020).
[7] In a typical year, about 10,000 schools across the nation administers NWEA assessments to kindergarten students. This means that the sample with complete SPED program data is only about 1% of schools with MAP assessment data.

Acknowledgements

First authorship is shared between the authors, who contributed equally to this work. The authors are grateful for helpful feedback from Meg Guerreiro, Nate Jensen, Andrew McEachin, and Erik Ruzek and for support with data analysis from Art Katsapis.

Declaration of Interest

The authors have no conflict of interest to declare.

Statement of Human Subjects Research

Data used in this study were deidentified and requirements for approval by the independent ethnics committee waived.

References

Alamo Heights Independent School District v. State Board of Education, 790 F.2d 1153 (5th Cir. 1986). https://law.justia.com/cases/federal/appellate-courts/F2/790/1153/8431/

Barnard-Brak, L. & Stevens, T. (2021). Criteria for determining eligibility for extended school year services. *The Journal of Special Education*, (1-10). DOI: 10.1177/0022466920911468

Barnard-Brak, L., Stevens, T., & Valenzuela, E. (2018). Barriers to providing extended school year services to students with disabilities: an exploratory study of special education directors. Rural Special Education Quarterly, 37(4), 245-250. DOI: 101177/8756870518772308

Bloom, H. S., Hill, C. J., Black, A. R., & Lipsey, M. W. (2008). Performance trajectories and performance gaps as achievement effect-size benchmarks for educational interventions. *Journal of Research on Educational Effectiveness, 1*(4), 289-328.

Boroson, B., Barker, E., Li, X. (2017). A longitudinal study of reading growth for students with visual impairments. *Journal on Technology & Persons with Disabilities*, *5*, 158-173.

Clements, D.H., Fuson, K.C., & Sarama, J. (2017). The research-based balance in early childhood mathematics: A response to common core criticisms. *Early Childhood Research Quarterly, 40,* 150-162. http://dx.doi.org/10.1016/j.ecresq.2017.03.005

Duff, D., Tomblin, B.J., & Catts, H. (2013). The influence of reading on vocabulary growth: A case for a matthew effect. *Journal of Speech, Language, and Hearing Research, 58*, 853-864.

Endrew F. v. Douglas County School District. 580 US _ (2017). https://www.supremecourt.gov/opinions/16pdf/15-827_0pm1.pdf.

Every Student Succeeds Act, 20 U.S.C. § 6301 (2015). https://www.congress.gov/114/plaws/publ95/PLAW-114publ95.pdf

Francis, D. J., Shaywitz, S. E., Stuebing, K. K., Shaywitz, B. A., & Fletcher, J. M. (1996). Developmental lag versus deficit models of reading disability: A longitudinal, individual growth curves analysis. *Journal of Educational Psychology, 88*(1), 3-17.

Gershenson, S. & Hayes, M. S. (2017). The summer learning of exceptional students. *American Journal of Education*, *123*, 447-473.

Gersten, R., Jordan, N.C., & Flojo, J.R. (2005). Early identification and interventions for students with mathematics difficulties. *Journal of Learning Disabilities*, *38*(4), 293-304.

Gilmour, A. F., Fuchs, D., & Wehby, J. H. (2019). Are students with disabilities accessing the curriculum? A meta-analysis of the reading achievement gap between students with and without disabilities. *Exceptional Children*, *85*(3), 329-346.

Hurwitz, S., Perry, B., Cohen, E., & Skiba, R. (2020). Special education and individualized academic growth: A longitudinal assessment of outcomes for students with disabilities. *American Educational Research Journal*, *57*(2), 576-611.

Individuals with Disabilities Education Act, 20 U.S.C § 1400 (2004). https://sites.ed.gov/idea/regs/b/b/300.111

Jackson Johnson v. District of Columbia. No. 1:2011cv00894 - Document 27 (D.D.C. 2012). https://law.justia.com/cases/federal/district-courts/district-of-columbia/dcdce/1:2011cv00894/148165/27/

Jacob, S., Decker, D. M., & Lugg, E. T. (2016). Ethics and law for school psychologists, 7th edition. Wiley.

Kim, J. S. & Quinn, D. M. (2013). The effects of summer reading on low-income children's literacy achievement from kindergarten to grade 8: A meta-analysis of classroom and home interventions. *Review of Educational Research, 83(3)*, 386-431. DOI: 10.3102/0034654313483906

Kohli, N., Sullivan, A.L., Sadeh, S., Zopluoglu, C. (2015). Longitudinal mathematics development of students with learning disabilities and students without disabilities: a comparison of linear, quadratic, and piecewise linear mixed effects models. *Journal of School Psychology*, *53*, 105-120.

Kuhfeld, M., Condron, D. J., & Downey, D. B. (2020). When does inequality growth? A seasonal analysis of racial/ethnic disparities in learning from kindergarten through eighth grade. *Educational Researcher,* 1-14. DOI: 10.3102/0013189X20977854

Lazarus, S. S., Albus, D., & Thurlow, M. L. (2016). *2013-2014 Publicly reported assessment results for students with disabilities and ELLs with disabilities (NCEO Report 401)*. https://nceo.umn.edu/docs/OnlinePubs/Report401/NCEOReport401.pdf

Levine, S. C., Surlyakham, L. W., Rowe, M. L., Huttenlocher, J., & Gunderson, E. A. (2010). What counts in the development of young children's number knowledge? *Developmental Psychology, 46(5),* 1309-1319.

McCombs, J. S., Augustine, C. H., Schwartz, H. L., Bodilly, S. J., McInnis, B., Lichter, D. S., & Cross, A. B. (2011). Making summer count how summer programs can boost children's learning. RAND Corporation.

Morgan, P. L., Farkas, G., & Wu, Q. (2011). Kindergarten children's growth trajectories in reading and mathematics: Who falls increasingly behind? *Journal of Learning Disabilities, 44*(5), 472-488.

National Assessment of Educational Progress. (2019). https://www.nationsreportcard.gov/ndecore/xplore/NDE

National Center for Education Statistics. (2017). Common core of data.

National Center for Education Statistics. (2020). Students with disabilities. https://nces.ed.gov/programs/coe/indicator_cgg.asp

National Council on Disability. (2018). Every Student Succeeds Act and students with disabilities. https://ncd.gov/sites/default/files/NCD_ESSA-SWD_Accessible.pdf

No Child Left Behind Act of 2001, P.L. 107-110, 20 U.S.C. § 6319 (2002).

Office for Civil Rights. (2020). Protecting Students with Disabilities. https://www2.ed.gov/about/offices/list/ocr/504faq.html

Oslund, E.L., Hagan-Burke, S., Taylor, A.B., Simmons, D.C., Simmons, L., Kwok, O., Johnson, C., & Coyne, M.D. (2012). Predicting kindergartners' response to early reading interventions: an examination of progress-monitoring measures. *Reading Psychology*, *33*(1-2), 78-103. DOI: 10.1080/02702711.2012.630611

Queenan, R. (2015). School's out for summer. But should it be? *Journal of Law & Education, 44*, 165-197.

Quinn, D. M., Cooc, N., McIntyre, J., & Gomez, C. J. (2016). Seasonal dynamics of academic achievement inequality by socioeconomic status and race/ethnicity: Updating and extending past research with new national data. *Educational Researcher*, *45*, 443–453.

Raudenbush, S. W., Bryk, A. S, Cheong, Y. F. & Congdon, R. (2019). HLM 8 for Windows [Computer software]. Scientific Software International, Inc.

Reed, D.K., Aloe, A.M., Reeger, A.J., & Folsom, J.S. (2019). Defining summer gain among elementary students with or at risk for reading disabilities. *Exceptional Children, 85(4)*, 413-431. DOI: 1177/0014402918819426.

Reed, D.K., Cook, K.M, & Aloe, A.M. (2020). A cost-benefit analysis of summer reading programs implemented under state guidelines. *Educational Policy, 34(4)*, 594-618. DOI: 10.1177/0895904818802112

Rosenberg, M. S., Sindelar, P. T., & Hardman, M. L. (2004). Preparing highly qualified teachers for students with emotional or behavioral disorders: The impact of NCLB and IDEA. *Behavioral Disorders*, *29(3)*, 266-278.

Sabia, R., Thurlow, M.L., & Lazarus, S. S. (2020). Developing IEPs that support inclusive education for students with the most significant cognitive disabilities. TIES Center Brief, (3) 1-8.

Schochet, O. N., Johnson, A. D., & Phillips, D. A. (2020). The effects of early care and education settings on the kindergarten outcomes of doubly vulnerable children. *Exceptional Children*, *81*(1), 27-53.

Schwartz, A. E., Hopkins, B. G., & Stiefel, L. (2021). The effects of special education on the academic performance of students with learning disabilities. *Journal of Policy Analysis and Management.* DOI:10.1002/pam.22282

Solari, E. J., Petscher, Y., & Folsom, J. S. (2014). Differentiating literacy growth of ELL students with LD from other high-risk subgroups and general education peers: Evidence from grades 3-10. *Journal of Learning Disabilities*, *47*(4), 329-348.

Stanovich, K.E. (1986). Matthew effects in reading: Some consequences of individual differences in acquisition of literacy. *Reading Research Quarterly*, *21*(4), 360-407.

Stanovich, K.E. (2000). Progress in understanding reading: Scientific foundations and new frontiers. New York, NY: Guilford.

Stelitano, L., Mulhern, C., Feistel, K., & Gomez-Bendaña, H. (2021). How are teachers educating students with disabilities during the pandemic? RAND Corporation, 2021. https://www.rand.org/pubs/research_reports/RRA1121-1.html.

Stevens, J. J. (2018). Did you know? Research note 15. National Center on Assessment and Accountability for Special Education. https://www.ncaase.com/docs/15_DYK_Interaction_LDxEL.pdf

Stevens, J. J. & Schulte, A. C. (2017). The interaction of learning disability status and student demographic characteristics on mathematics growth. *Journal of Learning Disabilities, 50*(3), 261-274.

Stevens, J. J., Schulte, A. C., Elliott, S. N., Nese, J. F. T., & Tindal, G. (2015). Growth and gaps in mathematics achievement of students with and without disabilities on a statewide achievement test. *Journal of School Psychology, 53*, 45-62.

Tatgenhorst, A., Norlin, J.W., & Gorn, S. (2014). *The answer book on special education law 6th edition*. LRP Publications.

Thum Y. M., & Hauser, C. H. (2015). NWEA 2015 MAP Norms for Student and School Achievement Status and Growth. NWEA Research Report. NWEA.

Thum, Y. M. & Kuhfeld, M. (2020). *NWEA 2020 MAP Growth norms for students and school achievement status and growth*. NWEA Research Report. NWEA.

Tindal, G. & Anderson, D. (2019). Changes in status and performance over time for students with specific learning disabilities. *Learning Disability Quarterly, 42*(1), 3-16.

U.S. Department of Education. (2017). *Questions and Answers (Q&A) on U. S. Supreme Court Case Decision Endrew F. v. Douglas County School District Re-1* (p. 1-9). Washington, DC. https://sites.ed.gov/idea/files/qa-endrewcase-12-07-2017.pdf

U.S. Department of Education. (2021). Our nation's English Learners: What are their characteristics? https://www2.ed.gov/datastory/el-characteristics/index.html

von Hippel, P. T., & Hamrock, C. (2019). Do test score gaps grow before, during, or between the school years? Measurement artifacts and what we can know in spite of them. *Sociological Science, 6*, 43–80.

von Hippel, P.T., Workman, J., & Downey, D.B. (2018). Inequality in reading and math skills form mainly before kindergarten: A replication, and partial correction, of "Are Schools the Great Equalizer?" *Sociology of Education*, *91*, 323-357. https://doi.org/10.1177/0038040718801760

Wanzek, J., Stevens, E.A., Willams, K. J., Scammacca, N., Vaugh, S., & Sargent, K. (2018). Current evidence on the effects of intensive early reading interventions. *Journal of Learning Disabilities*, *51*(6), 612-624.

Wei, X., Blackorby, J., & Schiller, E. (2011). Growth in reading achievement of students with disabilities, ages 7 to 17. *Exceptional Children*, *78*(1), 89-106.

Wei, X., Lenz, K. B., & Blackorby, J. (2012). Math growth trajectories of students with disabilities: Disability category, gender, racial, and socioeconomic status differences from ages 7 to 17. *Remedial and Special Education*, *34*(3), 154-165.

Wise, S. L., Pastor, D. A, & Kong, X. J. (2009). Correlates of rapid-guessing behavior in low-stakes testing: Implications for test development and measurement practice. *Applied Measurement in Education*, *22*(2), 185-205, DOI: 10.1080/08957340902754650

Tables and Figures

Table 1. Sample Characteristics

Math	All		Ever-SPED		Always-SPED		Ever EL+SPED		Never-SPED	
	N=4228		N=786		N=166		N=169		N=3442	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Female	0.49	0.50	0.35	0.48	0.36	0.48	0.37	0.48	0.53	0.50
Asian	0.02	0.13	0.01	0.08	0.01	0.08	0.01	0.08	0.02	0.14
Black	0.09	0.29	0.06	0.24	0.09	0.29	0.01	0.11	0.10	0.30
Hispanic	0.23	0.42	0.18	0.38	0.17	0.38	0.54	0.50	0.24	0.43
White	0.42	0.49	0.43	0.50	0.52	0.50	0.09	0.29	0.41	0.49
Reading	N=3744		N=732		N=163		N=133		N=3012	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Female	0.50	0.50	0.36	0.48	0.37	0.48	0.43	0.50	0.53	0.50
Asian	0.02	0.14	0.01	0.08	0.01	0.08	0.01	0.09	0.02	0.15
Black	0.09	0.29	0.06	0.24	0.09	0.29	0.02	0.12	0.10	0.30
Hispanic	0.14	0.35	0.12	0.33	0.17	0.37	0.43	0.50	0.15	0.35
White	0.47	0.50	0.46	0.50	0.53	0.50	0.11	0.32	0.47	0.50

Table 2. Estimated Monthly Growth Rates in School Year and Summer

	Math				Reading			
Grades	Ever-SPED	Always-SPED	EL-SPED	Never-SPED	Ever-SPED	Always-SPED	EL-SPED	Never-SPED
Intercept	137.517***	137.556***	134.053***	142.230***	135.321***	135.825***	132.880***	138.681***
	(0.374)	(0.803)	(0.766)	(0.191)	(0.397)	(0.754)	(0.920)	(0.195)
K Year	1.953***	1.878***	2.099***	2.175***	1.761***	1.626***	1.738***	2.026***
	(0.056)	(0.110)	(0.104)	(0.024)	(0.064)	(0.109)	(0.125)	(0.031)
K Summer	-1.201***	-0.892***	-0.629**	-0.699***	-1.278***	-1.095***	-0.721**	-0.411***
	(0.148)	(0.339)	(0.287)	(0.059)	(0.176)	(0.346)	(0.335)	(0.080)
G1 Year	2.348***	2.264***	2.308***	2.191***	2.175***	2.079***	2.220***	2.091***
	(0.051)	(0.137)	(0.106)	(0.021)	(0.060)	(0.145)	(0.135)	(0.026)
G1 Summer	-2.160***	-2.117***	-2.351***	-1.388***	-1.685***	-1.181**	-1.632***	-0.396***
	(0.147)	(0.386)	(0.310)	(0.061)	(0.194)	(0.478)	(0.443)	(0.093)
G2 Year	2.012***	1.631***	1.872***	1.926***	1.815***	1.618***	1.608***	1.918***
	(0.050)	(0.113)	(0.095)	(0.021)	(0.062)	(0.144)	(0.139)	(0.031)
G2 Summer	-1.706***	-0.767**	-1.543***	-1.399***	-1.060***	-0.799**	-1.116***	-0.770***
	(0.131)	(0.325)	(0.310)	(0.058)	(0.165)	(0.364)	(0.396)	(0.077)
G3 Year	1.599***	1.472***	1.574***	1.665***	1.439***	1.350***	1.513***	1.365***
	(0.049)	(0.115)	(0.104)	(0.021)	(0.062)	(0.145)	(0.131)	(0.025)
G3 Summer	-1.849***	-1.451***	-1.838***	-1.431***	-1.535***	-0.914**	-1.429***	-0.873***
	(0.137)	(0.364)	(0.292)	(0.057)	(0.170)	(0.402)	(0.423)	(0.070)
G4 Year	1.421***	1.414***	1.216***	1.561***	1.265***	1.356***	1.171***	1.018***
	(0.052)	(0.144)	(0.119)	(0.021)	(0.059)	(0.150)	(0.125)	(0.025)
Tests	8958	1597	1903	33955	8305	1527	1503	29743
Students	786	166	169	3442	732	163	133	3012
Intercept-Variance	129.10	146.60	107.20	97.38	146.40	150.00	133.30	112.20

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. SPED=special education. EL=English Learner. K= kindergarten. Intercept = predicted score on the first day of kindergarten. G1 Year= grade 1 school year. G1 Summer = summer after grade 1.

Figure 1. Observed Mean Achievement by Special Education Placement

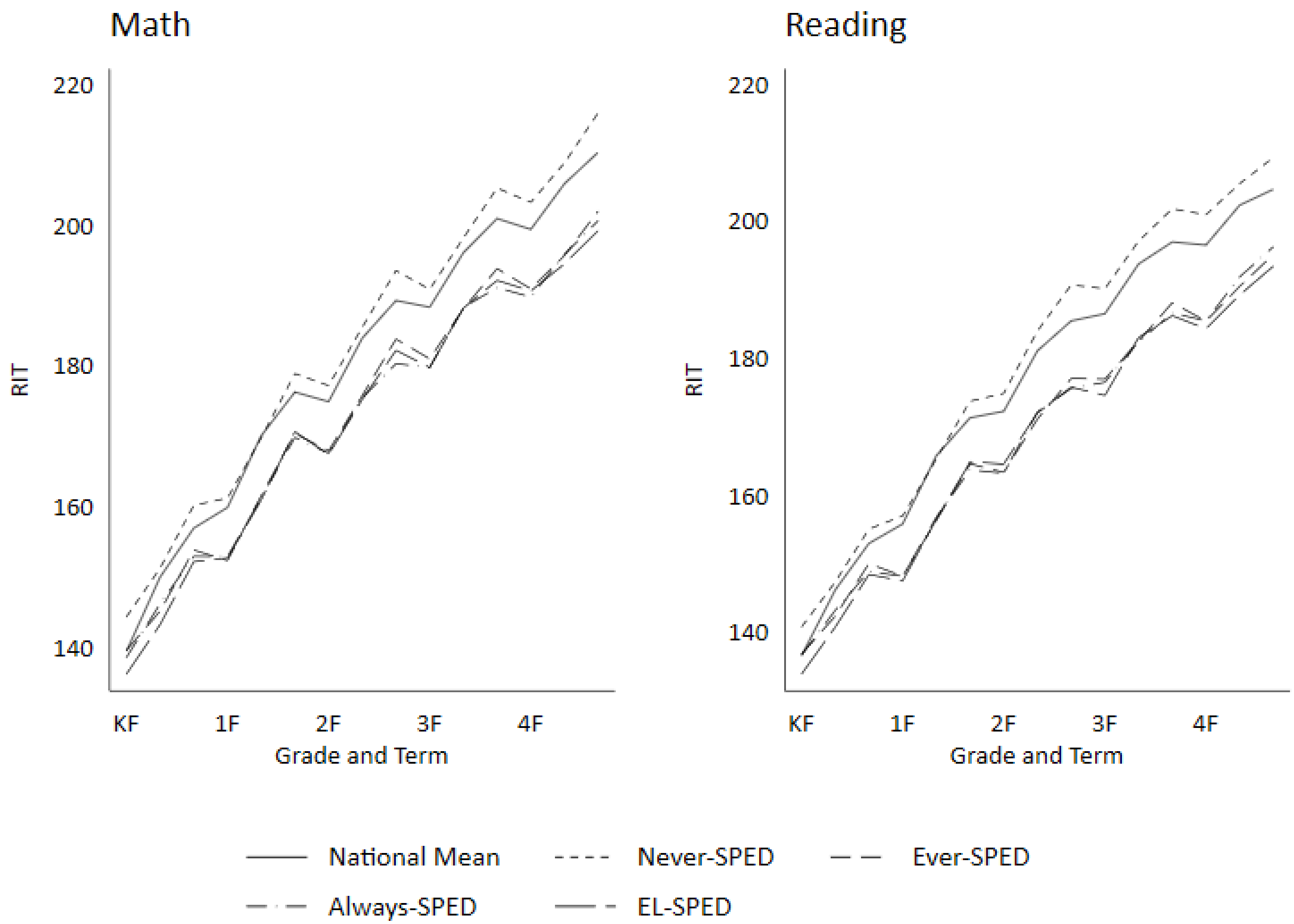


Figure 2a. Model-Estimated Monthly Growth Rates in School Year and Summer (Math)

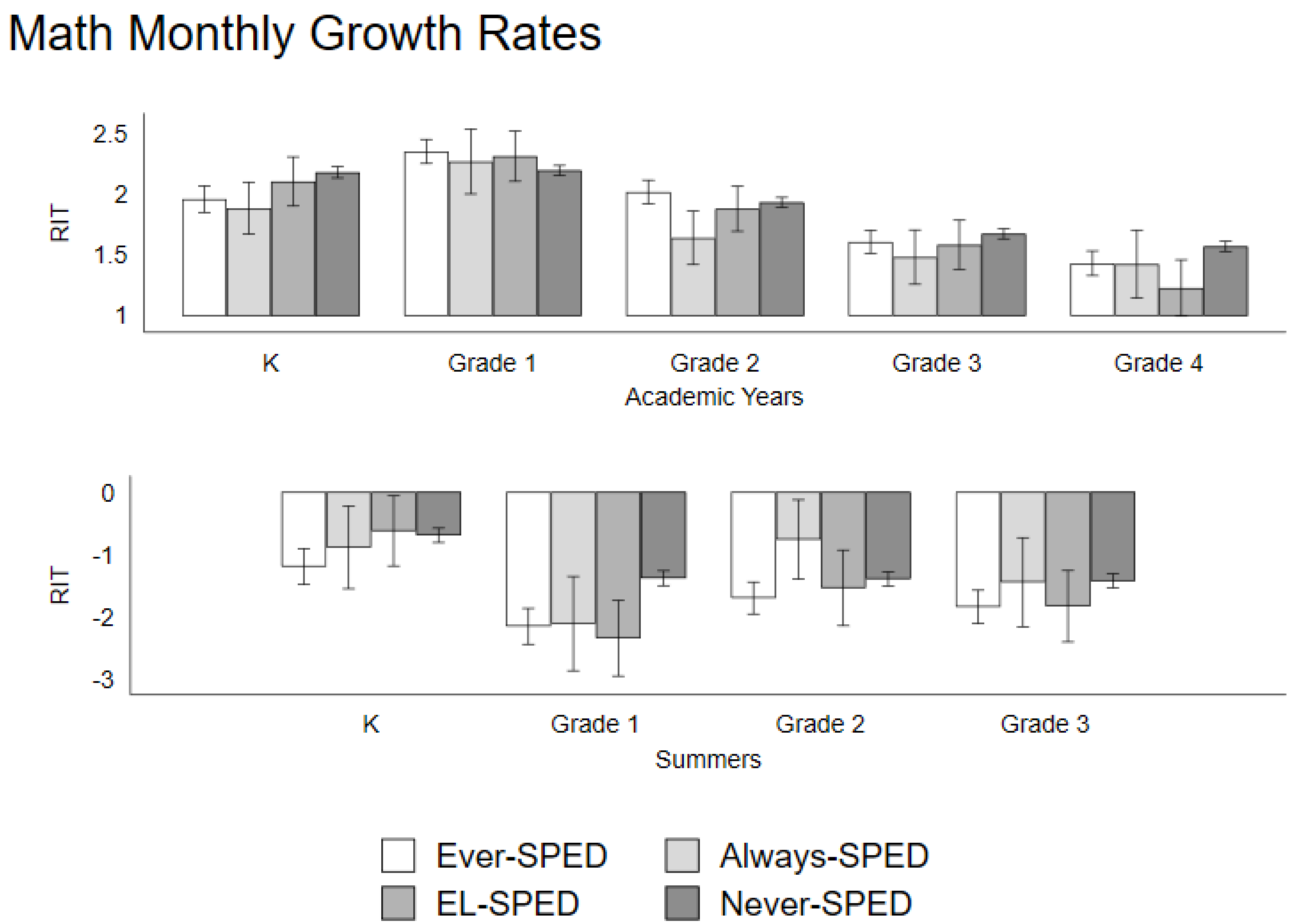
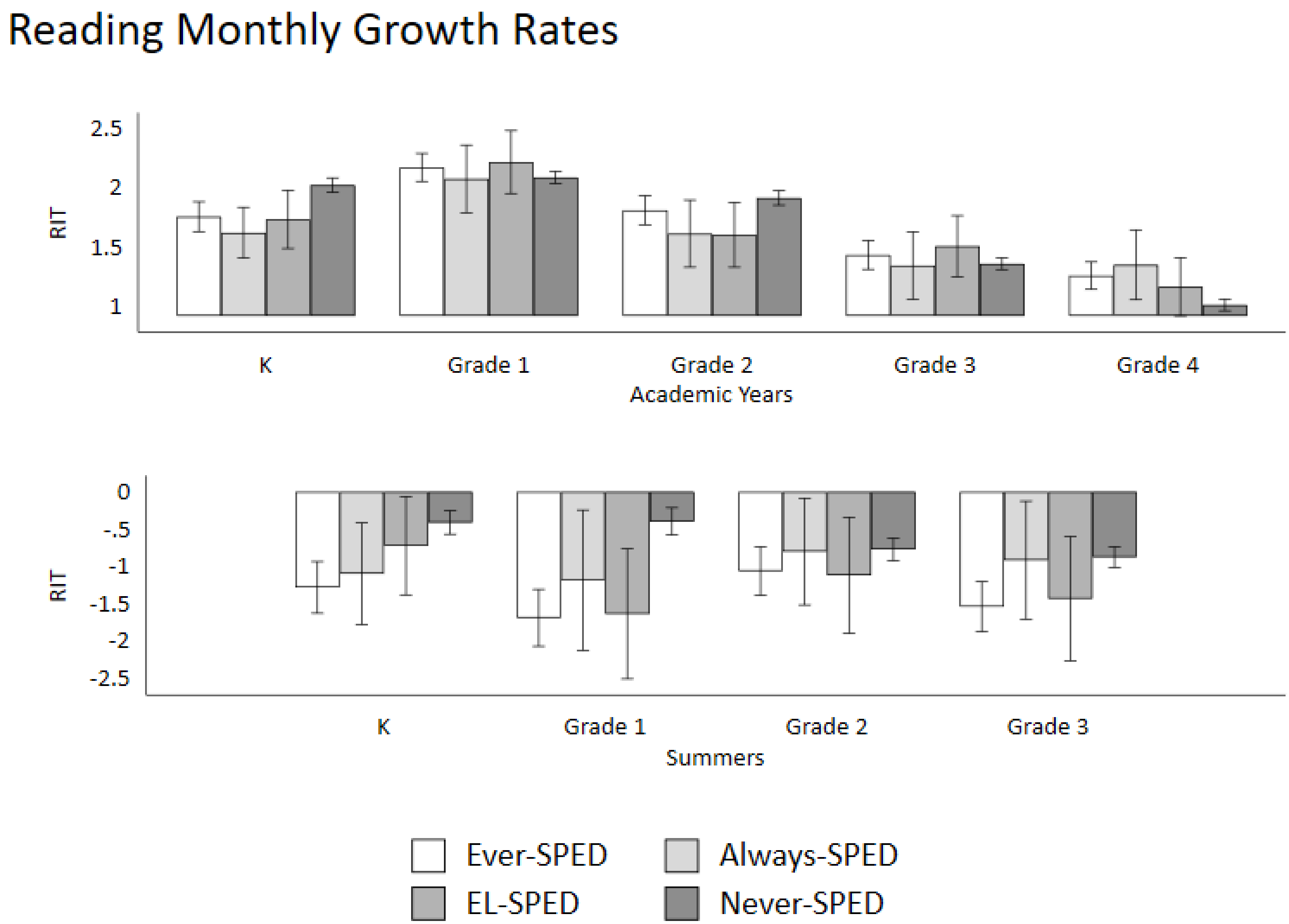


Figure 2b. Model-Estimated Monthly Growth Rates in School Year and Summer (Reading)



Supplemental Tables and Figures

Table A1. Characteristics of Sample Schools Versus All Public Schools

	Sample Schools			ALL NCES Public Schools Serving Kindergarten		
	Mean	SD	N	Mean	SD	N
% FRPL	0.66	0.28	109	0.55	0.30	55119
% Asian	0.01	0.03	109	0.04	0.09	55294
% Black	0.07	0.18	109	0.15	0.24	55294
% Hispanic	0.14	0.23	109	0.25	0.29	55294
% White	0.53	0.40	109	0.50	0.34	55294
City	0.15	0.36	109	0.30	0.46	55824
Town	0.17	0.38	109	0.11	0.31	55824
Rural	0.57	0.50	109	0.26	0.44	55824
Title I Eligible	0.90	0.30	109	0.77	0.42	55377
School-wide Title I	0.78	0.42	107	0.66	0.47	55010

Table A2. Number of Students Tested by Grade and Term

Panel A:	N students		**Panel B:**	Math			Reading		
By Grade/Term	Math	Reading	**By Total N Terms**	N Students	%	Cumul. %	N Students	%	Cumul. %
Fall K	3079	2932	1	189	4.47	4.47	168	4.49	4.49
Winter K	3367	3094	2	235	5.56	10.03	240	6.41	10.90
Spring K	2452	1947	3	210	4.97	15.00	179	4.78	15.68
Fall G1	3064	2835	4	103	2.44	17.43	105	2.80	18.48
Winter G1	3095	2567	5	151	3.57	21.00	128	3.42	21.90
Spring G1	3302	2869	6	135	3.19	24.20	121	3.23	25.13
Fall G2	2848	2558	7	91	2.15	26.35	74	1.98	27.11
Winter G2	3047	2526	8	130	3.07	29.42	117	3.13	30.24
Spring G2	3145	2702	9	213	5.04	34.46	170	4.54	34.78
Fall G3	2572	2556	10	331	7.83	42.29	204	5.45	40.22
Winter G3	2814	2410	11	264	6.24	48.53	240	6.41	46.63
Spring G3	2891	2480	12	390	9.22	57.76	341	9.11	55.74
Fall G4	2253	2276	13	279	6.60	64.36	258	6.89	62.63
Winter G4	2426	2090	14	1,065	25.19	89.55	1,010	26.98	89.61
Spring G4	2558	2206	15	442	10.45	100.00	389	10.39	100.00
			Total	4,228	100.00	100.00	3,744	100.00	100.00

Notes: N = number. K=kindergarten. G1 = Grade 1. Cumul = cumulative. Panel A presents the number of students tested in each grade/term. Panel B presents the number of students with available test scores for each corresponding number of terms (e.g., 189 students had test scores for 1 term; 442 students had scores for all 15 terms.

Table A3. Sample Mean RIT Scores by Grade and Term

	Math				Reading			
Test Term	Ever-SPED	Always-SPED	EL-SPED	Never-SPED	Ever-SPED	Always-SPED	EL-SPED	Never-SPED
K Fall	139.7	138.7	136.3	144.5	136.9	136.7	134.0	140.9
K Winter	145.3	146.3	143.4	151.4	142.5	143.3	140.8	147.4
K Spring	154.0	153.1	152.3	160.4	150.1	149.0	148.5	155.2
G1 Fall	152.5	153.1	152.9	161.4	148.3	148.3	147.6	157.1
G1 Winter	161.7	161.4	161.1	169.9	156.5	156.9	156.6	165.4
G1 Spring	170.5	169.9	170.8	179.0	164.7	163.9	165.0	173.8
G2 Fall	168.0	167.7	167.5	177.3	163.5	163.3	164.7	175.0
G2 Winter	175.9	175.6	175.4	185.6	171.2	172.3	172.1	184.1
G2 Spring	183.9	180.4	182.3	193.7	177.2	175.7	175.9	190.8
G3 Fall	181.1	179.9	179.9	191.0	177.1	176.6	174.7	190.3
G3 Winter	188.3	188.5	188.3	198.3	182.6	182.5	183.1	197.3
G3 Spring	194.0	191.3	192.3	205.4	188.2	186.7	186.3	202.0
G4 Fall	191.1	189.9	190.8	203.4	185.6	185.6	184.4	201.1
G4 Winter	195.8	196.0	194.6	209.0	190.6	192.0	189.4	205.7
G4 Spring	202.2	200.8	199.4	216.1	195.3	196.4	193.6	209.5

Notes: K=kindergarten. G1 = Grade 1. SPED=special education. EL=English Learner.

Table A4. Estimated Monthly Growth Rates for School Year and Summer, Students Tested in 8 or More Terms

	Math				Reading			
Growth Terms	Ever-SPED	Always-SPED	EL-SPED	Never-SPED	Ever-SPED	Always-SPED	EL-SPED	Never-SPED
Intercept	137.562***	137.801***	133.926***	143.070***	135.173***	135.903***	132.705***	139.602***
	(0.398)	(0.977)	(0.814)	(0.215)	(0.428)	(0.944)	(0.973)	(0.224)
K Year	1.998***	2.001***	2.146***	2.202***	1.824***	1.705***	1.794***	2.034***
	(0.061)	(0.141)	(0.114)	(0.027)	(0.069)	(0.146)	(0.137)	(0.036)
K Summer	-1.231***	-0.982**	-0.775***	-0.704***	-1.357***	-0.987**	-0.984***	-0.351***
	(0.160)	(0.394)	(0.300)	(0.065)	(0.186)	(0.402)	(0.351)	(0.090)
G1 Year	2.325***	2.240***	2.309***	2.200***	2.166***	2.081***	2.229***	2.090***
	(0.054)	(0.149)	(0.112)	(0.022)	(0.062)	(0.151)	(0.145)	(0.028)
G1 Summer	-2.159***	-2.174***	-2.369***	-1.422***	-1.695***	-1.382***	-1.616***	-0.368***
	(0.151)	(0.397)	(0.323)	(0.063)	(0.199)	(0.488)	(0.466)	(0.096)
G2 Year	2.019***	1.638***	1.877***	1.922***	1.837***	1.629***	1.607***	1.905***
	(0.051)	(0.112)	(0.096)	(0.022)	(0.063)	(0.143)	(0.141)	(0.031)
G2 Summer	-1.710***	-0.767**	-1.527***	-1.399***	-1.107***	-0.792**	-1.057***	-0.784***
	(0.131)	(0.324)	(0.311)	(0.058)	(0.165)	(0.362)	(0.398)	(0.077)
G3 Year	1.602***	1.473***	1.573***	1.668***	1.442***	1.348***	1.498***	1.367***
	(0.049)	(0.114)	(0.104)	(0.021)	(0.062)	(0.145)	(0.132)	(0.025)
G3 Summer	-1.855***	-1.451***	-1.838***	-1.436***	-1.521***	-0.912**	-1.382***	-0.878***
	(0.138)	(0.364)	(0.297)	(0.057)	(0.171)	(0.402)	(0.427)	(0.070)
G4 Year	1.425***	1.415***	1.212***	1.564***	1.258***	1.356***	1.173***	1.018***
	(0.052)	(0.143)	(0.120)	(0.021)	(0.059)	(0.150)	(0.126)	(0.025)
Tests	8465	1417	1793	30545	7825	1345	1399	26734
Students	672	111	145	2442	620	107	110	2109
Intercept-Variance	130.40	162.20	104.40	89.70	154.80	180.50	129.20	115.20

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. K=kindergarten. G1 = Grade 1. SPED=special education. EL=English Learner. Sample includes students who had available test scores for 8 or more test terms.

Appendix B. Calculating months of exposure to school

To set up the design matrix for this seasonal learning model, I calculate three sets of time variables: (a) number of months in school prior to testing, (b) total number of months spent in school across the whole school year, and (c) months of summer vacation. Time before testing was calculated as the difference between the school start date and test administration date for each student. The total number of months in school is calculated as the end date subtracted by the school start date, divided by 30.25 days per month. The months of summer vacation is the fall school start date subtracted by the prior year spring end date, divided by 30.25 days per month. For example, if a student tests in the fall of 1st grade, they have been exposed to all of kindergarten, a couple months of summer vacation after kindergarten, and one or two months of 1st grade. Since they have not been exposed to another summer vacation or 2nd grade, the values for those predictors are set to zero.

Table B1. Monthly Exposure Rates for a Hypothetical Student Testing in Kindergarten and 1st Grade

				Monthly Exposure Design Matrix					
Grade/Term	School Start Date	School End Date	Test date	Int.	K	SumK	G1	Sum1	G2
Fall K	8/20/2014	6/12/2015	9/1/2014	1.00	0.39	0.00	0.00	0.00	0.00
Winter K	8/20/2014	6/12/2015	12/1/2014	1.00	3.39	0.00	0.00	0.00	0.00
Spring K	8/20/2014	6/12/2015	5/1/2015	1.00	8.23	0.00	0.00	0.00	0.00
Fall 1st	8/19/2015	6/11/2016	9/15/2015	1.00	9.82	2.25	0.89	0.00	0.00
Winter 1st	8/19/2015	6/11/2016	11/20/2015	1.00	9.82	2.25	3.11	0.00	0.00
Spring 1st	8/19/2015	6/11/2016	4/1/2016	1.00	9.82	2.25	7.26	0.00	0.00