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Research Brief

Study of Over 30,000 K-8th Graders Shows Steepest Learning Occurs Before 3rd Grade

Claire E. Cameron, Kevin J. Grimm, Joel S. Steele, Laura Castro-Schilo & David W. Grissmer

This study used two large-scale data sets, representing over 30,000 children, to examine the shape of U. S. students' growth in reading and mathematics from kindergarten through eighth grade. This study found that a specific shape of non-linear growth—an S-shaped Gompertz curve that has been used to describe growth in biological and social phenomena—also characterizes achievement growth.

Any parent or teacher can tell you that children don't learn in a steady, linear fashion. When children learn to read, they must first master hundreds of facts, like basic knowledge of letter names and shapes, and the understanding that letters can be combined in different ways to spell different words. These skills form a foundation upon which later reading for understanding is built. Math learning is similar, where children learn many concepts, such as recognizing numbers, counting, and understanding one-to-one correspondence, and then build on these basic early quantitative concepts.

Thus many individual skills must be learned before students can progress to later skills. The few studies that exist that address these issues suggest that achievement growth is not linear, and specifically, that students learn more in elementary school than middle school.

Still, questions remain about how and when in the primary schooling period children accomplish the most learning in reading and math. Non-linearity is difficult to capture accurately in research because many studies collect only a few time points on children's skills in a given subject like reading or math. Measuring these changing skills is also difficult: alphabet letter knowledge versus comprehension of text is like comparing apples to oranges.

In sum, while developmental and educational theories acknowledge that achievement growth is non-linear—and include, for example, periods of rapid change followed by slower periods of change that tapers—few analytic models are available to accurately describe this complexity.

The Study

The goal of this study was to apply non-linear growth models to two large data sets that included up to seven time points assessing children's achievement in reading and mathematics. We wanted to know how much learning children accomplished in emelentary and middle school, when during the K-8th grade period their growth was the fastest, and when their learning shifted from faster to slower. Note that we assumed continually increasing change throughout the period, but we allowed the rate of growth to be different at different times.

Participants were from the National Longitudinal Survey of Youth—Children and Young Adults (NLSY-CYA; n=9,032) and the Early Childhood Longitudinal Study of Kindergarten (ECLS-K; n=21,260). Because their parents were the original participants in the 1970s, NLSY-CYA students' data spanned a wider range of years, but most attended elementary school in the 1990s. Their reading and math skills were measured with a commonly used assessment, the Peabody Individual Achievement Tests or PIAT. ECLS-K students were all in kindergarten in 1998-99, and they were assessed with study-specific measures that were vertically-equated. This means the measures can be used to compare children's scores across all ages (e.g., a child's kindergarten score can be compared to their 8th grade score). This research brief focuses on findings from the ECLS-K data.

We tested three types of non-linear models to find the one that best described the data. All models tested were S-shaped, which means

they assumed slow initial growth, followed by a period of accelerated (fast) growth, and ending with slow growth. The difference between the models was in the number of constraints, and the relative rates of change and different time points.

Findings

We found that the Gompertz curve, which has been used to describe the rate of biological and social phenomena like tumor growth and cell phone ownership[1] fit both math and reading achievement best in both data sets. Model parameters suggested that most children, on average, achieved their fastest growth relatively early in the K-8th period; see **Figure 1**.

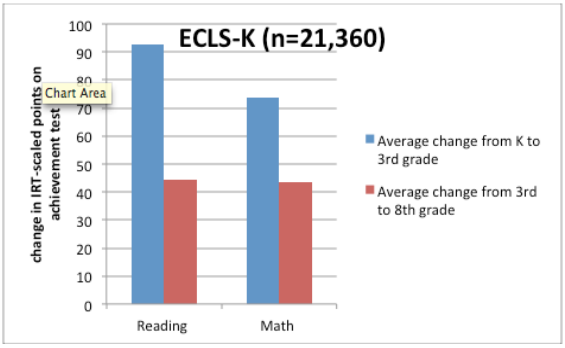

Figure 1: Children Grow More Before 3rd Grade

Specifically, we found that in the more recent ECLS-K data, most children achieved their fastest rate of growth in the middle of 1st grade for reading, and the beginning of 1st grade for math. In ECLS-K, the children who grew at a faster rate and changed earlier grew more by the end of 8th grade, compared to those children who grew at a slower rate and changed later.

Finally, we found that socio-demographic variables explained differences in how children grew, and that these differences matched other findings in the literature. The largest gaps emerged from differences in parents' educational backgrounds, and there were cumulative advantages for each education level. In the ECLS-K, having a mother, or father, who graduated from high school, or from college, meant separate boosts to more total growth, faster growth, or earlier change. See **Figure 2.**

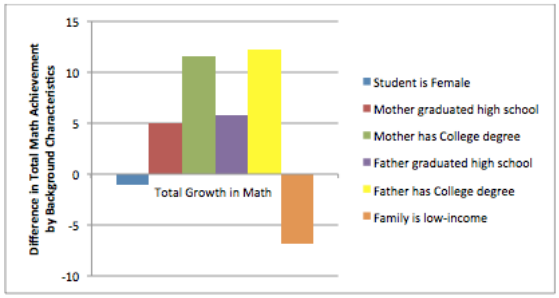

Figure 2: Advantages from Parents' Education in Students' Total Math Achievement

Implications

This study revealed that students grow in a specific pattern from kindergarten to 8th grade: they learn the most early in elementary school, due in part to achieving their fastest growth before 3rd grade. In addition, in the most recent ECLS-K data set, children from more socio-demographically advantaged backgrounds learned more by 8th grade because they learned at a faster rate earlier.

Results encourage researchers—and funders of research—to measure development over longer periods of schooling, using measures that can be compared over time. Importantly, these findings underscore economists' advice to invest heavily in the early years of education, by showing that this is the period when the average student is learning the most.

[1] http://www.livemint.com/Opinion/hpLZ8P5n6fkJtBE-4QsFqNL/The-cellerati-slowdown.html

This research brief is based on the following study and should be cited as follows: Claire E. Cameron, Kevin J. Grimm, Joel S. Steele, Laura Castro-Schilo & David W. Grissmer, Nonlinear Gompertz Curve Models of Achievement Gaps in Mathematics and Reading, Journal of Educational Psychology.

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