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Measuring Math Growth: Implications for Progress Monitoring*

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ABSTRACT
Achievement growth in math is often framed in the context of monitoring student progress within a Response to Intervention (RTI) approach to teaching and learning. In this research brief we report on a study that examined initial status and within-year growth for fourth grade students who received short progress-monitoring assessments in math during the 2011-2012 school year. Our results suggested that while growth in math was statistically observable and linear, given the amount of growth relative to the 16-point scale of the progress-monitoring probes used, it might have limited utility to teachers operating within an RTI framework. Additional research on within-year growth in math is suggested, especially as it relates to the influence of assessment design and instructional practices on such growth.

As Response to Intervention (RTI) approaches are adopted in schools, educational decision-makers turn to researchers and measurement developers for guidance on how best to determine if their students are making sufficient progress in developing their mathematics skills and knowledge. To date, the research community has provided only sparse advice. Of the 578 studies analyzed in a 2007 review[2], only 32 focused on math. Of these, only 9 included an analysis of growth slopes. More recently, a 2012 review[3] reported 27 studies in which expected weekly math growth was analyzed, but only 3 of these studies included students beyond first grade. The metric of growth most frequently reported in the 2012 study was number of digits correctly identified. Although this information may well be instructive for teachers in the early primary grades, it is likely an insufficient metric for measuring the more complex mathematical understanding expected of students as they move beyond early elementary grades.

To measure such skills, more complex assessments are needed. The easyCBM[4] screening and progress monitoring assessments were created to address this need, with measures intended for use with students in grades K-8. The measures draw from national standards for mathematical knowledge (both the National Council of Teachers of Mathematics Focal Point Standards and the Common Core State Standards were integral parts of item development) and were developed using the principles of Universal Design for Assessment[5] to facilitate their appropriateness for students with diverse access-skill challenges. The easyCBM assessments, composed of selected response items, each with three possible answer choices, are optimized for computer-based administration and scoring, although paper-pencil administration is also available. Item Response Theory was used during instrument development to facilitate the creation of multiple alternate forms of comparable difficulty, which schools use for thrice-yearly screening of students and more regular progress monitoring of students who have been identified as needing additional targeted instruction to catch up to their grade-level peers. The easyCBM assessments have been widely adopted in schools across the United States, and have been administered to well over 2 million students.

Unlike reading measures such as oral reading fluency (ORF), which have been the mainstay of educators monitoring the progress their students are making in developing important reading skills, growth on math assessments may well be constrained by assessment design. For example, educators familiar with expecting growth of one word per week (which has been documented in numerous studies of reading CBM[6]) may find themselves perplexed about how best to conceptualize growth on mathematics measures with a discrete and finite score range.
We analyzed data from a SY 2011-2012 sample of

2,189 fourth-grade students from 105 schools, across 89 districts, and 24 states to answer the following research questions: (a) What are the characteristics of student growth observed with a short 16-item Number and Operations mathematics progress monitoring assessment in Grade 4? and (b) Does performance on the fall math interim benchmark assessment predict students' progress monitoring intercepts and/or slopes on Number and Operations mathematics progress monitoring assessments?

Figure 1. Results showing statistically-significant linear growth on easyCBM math measures.

Fixed Effects	Final Model	
	Coefficient	SE
Intercept, β_{00}	10.69	0.09
Winter start, β_{01}	0.56	0.12
Spring start, β_{02}	1.79	0.25
MATH, β_{03}	0.25	0.01
Linear Slope, β_{10}	0.20	0.02
Winter start, β_{11}		
Spring start, β_{12}		
MATH, β_{13}	< 0.01†	< 0.01
Quadratic Slope, β_{20}		
Random effects	**Estimate**	
Within student, $e_{i(jk)}$	3.19	
Btwn student intercept, r_{0j}	0.97	
Btwn student linear, r_{1j}	0.02	
Btwn student quadratic, r_{2j}		
Btwn school intercept, u_{00}	0.36	
Btwn school benchmark on intercept, u_{03}	< 0.01	
Btwn school linear, u_{10}		
Btwn school benchmark on linear, u_{13}	< 0.01	
Btwn school quadratic, u_{20}		
Model deviance (*df*)	40450.49 (16)	

† Coefficient is *not* significant, $p > .05$; All other values significant, $p < .05$.

Final Results

Fall BM = sig predictor of initial PM intercept, but not growth over time.
Varied by student & school
Growth = linear, .2 per month

For every point a student earned over the grand mean of 10.69, they scored an additional .25 point on their initial PM intercept.

Pseudo R2 = .756.
Including Fall BM score accounted for 75% of the student-level variance

We found that the fall benchmark screener assessment was a significant predictor of initial progress monitoring measure intercept, but not a significant predictor of student growth over time. For every point a student earned over the grand mean of 10.69, they scored an additional .25 point on their initial PM intercept. We also found that growth followed a linear pattern, with an increase of 0.2 points per month. In other words, students being progress monitored in mathematics over the course of the year grew on average 1 point (out of a possible 16) every five months (see Figure 1).

Implications for the Field

As researchers and practitioners continue to grapple with how best to document growth in mathematics knowledge and skill over time, particularly for students who have moved beyond simple fluency-based measures, it is important to keep in mind that we may need to reconceptualize what it means for students to show adequate growth. An improvement of 1 point out of 16 every five months of instruction may be statistically-significant, but is this growth sufficient to substantively inform educators about the effectiveness of the interventions and instruction they are providing to at-risk students? Scale-restricted interim-formative mathematics assessments have limitations in their ability to provide educators with clearly visible improvements over time, and thus, they may also have limited utility in RTI applications.

Three possible avenues for further exploration are evident: (a) increasing the number of items administered to students on mathematics progress monitoring measures to allow for greater variability in score range, (b) providing professional development specific to the nuances of interpreting growth in mathematics when using scale-restricted assessments, and (c) altering the scale on which math performance is reported, for example, moving from reporting raw scores to reporting scale scores (requiring vertical and horizontal scaling of assessments for greatest effect).

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