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Exploring gains in reading and mathematics achievement among regular and exceptional students using growth curve modeling☆

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ABSTRACT

Using four-wave longitudinal reading and mathematics data (4th to 7th grades) from a large urban school district, growth curve modeling was used as a tool for examining three research questions: Are achievement gaps closing in reading and mathematics? What are the associations between prior-achievement and growth across the reading and mathematics domains? Is there an association between the receipt of additional services (special education, English-as-second-language, free and reduced lunch program) and reading and mathematics achievement? Results showed that rates of growth in achievement diminished over time and achievement gaps closed in reading, but not mathematics. Reading ability was directly related to gains in mathematics. Analysis of the time-varying covariates showed that there tended to be positive effects of the receipt of English-as-second language instruction on both reading and mathematics achievement, whereas students receiving special education and free and reduced lunch programs consistently had lower academic achievement levels. Implications for the achievement literature are discussed.

1. Introduction

Broadly speaking, there are two prominent views regarding what is required to close achievement gaps between children of various ethnic, disability, and language backgrounds. The first view is preventive. According to this view, all children enter school eager and ready to learn. Once first grade has begun, schools must prevent disadvantaged children from falling behind (Johnson, 2002). The second view is reparative. According to this view, children from disadvantaged backgrounds enter school less well prepared, and therefore are already behind at the beginning of the educational process. After first grade has begun, schools must help disadvantaged students catch up, not merely prevent them from falling behind. Much of the evidence on school readiness would favor this second perspective (Davison, Seok Seo, Davenport, Butterbaugh, & Davison, 2004; Hart & Risley, 1995; Lee & Burkham, 2002). To catch-up, students who are initially behind must make greater progress than their peers. The tracking of progress then, is very important in order to assess whether stragglers are making greater gains. One tool for tracking progress is latent growth modeling (LGM; Willett & Sayer, 1994).

In this study, we used LGM to simultaneously study reading and mathematics trajectories over time in a large cohort of students and to examine several critical issues related to potential changes in achievement gaps over time. These include (1) examination of whether achievement gaps in reading and mathematics close or widen over time, (2) the associations between prior achievement and growth across the reading and mathematics domains, and (3) the association between additional services (special education program [SpEd], English-as-second-language [ESL], free and reduced lunch program [FRL]) and achievement in reading and mathematics. A preliminary issue in any growth curve modeling is the selection of an appropriate form of the growth curve. Examination of the research questions above implies a need for a growth curve model that adequately accounts for change over time in both reading and mathematics.

2. Literature review

2.1. Growth trajectories of reading and mathematics achievement

Reading and mathematics are considered foundational to K-12 knowledge and skills. Thus, academic growth analysis of reading and mathematics is one of the most important topics in educational research and accountability. Although the patterns of academic growth are not always consistent from subject to subject and from grade to grade, most studies (CTB/McGraw-Hill, 2003; Ding, Davison, & Petersen, 2005;

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Harcourt Educational Measurement, 2002; Lee, 2010) found a decelerating rate of growth over the course of schooling. Based on long-term cohort analysis of national standardized tests (National Assessment of Educational Progress [NAEP], Comprehensive Test of Basic Skills), Lee (2010) concluded that the overall growth patterns characterized by diminishing rates of growth over ages/grades are very similar for both reading and mathematics. The author posited that the deceleration in growth stems from decreasing rates of growth in child cognitive capacity for acquiring new knowledge and skills at the older ages and from the increasing difficulty and complexity of school curricula and instruction at higher grades.

It seems true that as time goes on, mathematical concepts become increasingly abstract and complex, demanding a thorough understanding of mathematics learned in earlier grades (Carraher & Schliemann, 2007; Kieran, 2007). Paris (2005) and Paris and Luo (2010) noted that some reading skills (e.g., alphabet knowledge, phonics) are constrained to small sets of knowledge that can be mastered in relatively brief periods of development. Such constrained reading skills are more likely to show ceiling effects at an earlier stage and develop along nonlinear trajectories. Paris (2005), however, recognized that unequal learning ability and increasing task difficulty might cause developmental limits in unconstrained skills (e.g., vocabulary and reading comprehension).

2.2. Academic achievement gap

Prior reading and mathematics studies regarding achievement gaps led to inconsistent conclusions. Some found a Matthew effect, a term denoting the phenomenon that the achievement rich get richer and the achievement poor get poorer over time, whereas some others reported decreasing or unchanging gaps. Inconsistencies in findings may be attributable to differences in selected measures and their technical limitations (e.g., ceiling effects), in the samples and grade spans that are studied, in the subject areas that are studied, in the form of the growth model on which conclusions are based, and differences in the instruction received by students in the various studies (Paris, 2005; Parrila, Aunola, Leskinen, Nurmi, & Kriby, 2005). Tables 1 and 2 summarize the results of a number of achievement gap studies according to grade, sample, and tests. Mathematics studies generally suggest that achievement gaps tended to increase or at least sustain. In the case of reading, it was hard to find any specific patterns according to sample and test grades, although the achievement gaps with Woodcock Johnson tests tended to reduce. As described above, if the reading tests contain items related to constrained skills, ceiling effects in reading scores are more likely to appear, and these could cause declining reading gaps. Regardless of inconsistency, most studies noted that declines in academic gaps tended to be very slow or nonexistent.

2.3. Association of growth across subject areas

The U.S. Department of Education, Office of the Under Secretary (2003) and several studies (Armbuster, Lehr, & Osborn, 2001; Gaddy, 2003; Hallahan, Lloyd, Kauffman, Weiss, & Martinez, 2004) suggest that language proficiency is significantly related to development of cognitive skills. At a given point in time, the correlation between reading status and mathematics status can be substantial.

Table 1
Achievement gap studies in reading.

	Article	Sample	Grade	Test
Increasing Gap	Abedi et al. (2005)	N = Thousands (nationwide school districts)	3rd to 8th and 2nd, 7th, 9th	Iowa Tests of Basic Skills (ITBS) and Stanford 9 Subtests
	Anderson, Wilson, and Fielding (1988)	N = 155 (two schools in an urban city)	2nd and 5th	Stanford and Metropolitan Achievement tests
	Aunola, Nurmi, Niemi, Lerkkanen, and Rasku-Puttonen (2002)	N = 111 (4 schools in one town)	Five times in age 6–7	Beginners' Reading test
	Bast and Reitsma (1998)	N = 280 (40 Dutch schools)	1st to 3rd(7 time points)	4 domains with multiple tests
	Butler and Castellon-Wellington (2005)	N = 778 and N = 184 (two school districts)	3rd and 11th	Stanford 9 Subtests LAS Subtests
	Catts, Bridges, Little, and Tomblin (2008)*	N = 604	2nd to 10th (4 time points)	Woodcock Reading Mastery Test and GORT
	Cunningham and Stanovich (1997)	N = 56 (one class)	1st and 11th	Multiple different tests
	Seltzer et al. (2003)	N = 16,632 (LSAY sample)	7th to 10th	LSAY reading test
	Williamson et al. (1991)*	N = 529 (one school district)	1st to 8th	Prescriptive Reading Inventory and California Achievement test (C)
Decreasing Gap	Aarnoutse and van Leeuwe (2000)	N = 900 (39 Dutch schools)	Cohort A (1st to 6th) B (2rd to 6th) C (3rd to 6th)	Four domains with multiple tests
	Catts, Hogan, and Fey (2003)	N = 604	Kindergarten to 4th	Different instruments for each grade
	Crijnen et al. (1998)*	N = 363 (schools in a urban city)	1st to 5th	CAT (California Achievement test)
	Han (2008)	N = 14,000 (Early Childhood Longitudinal Survey–Kindergarten Cohort)	Kindergarten to 3rd	Early Childhood Longitudinal Survey Kindergarten Cohort (ECLS-K) reading test
	Jordan, Kaplan and Hanich (2002)*	N = 180 (one area in a state)	2rd to 3rd (4 times)	Woodcock–Johnson Broad Mathematics composite tests
	Parrila et al. (2005)*	N = 198 (schools in a state)	1st to 5th	Woodcock Reading Mastery tests
	Phillips, Norris, Osmond, and Maynard (2002)	N = 187 (a rural school district)	1st to 6th	Gates–MacGinitie Reading tests
	Rescorla and Rosenthal (2004)*	N = 328 (a rural school district)	3rd, 5th, 8th,10th	Test of Cognitive Skills (TCS) and Comprehensive Tests of Basic Skills (CTBS)
	Scarborough and Parker (2003)	N = 57 (a school in one state)	2rd and 8th	Woodcock Johnson test
	Shaywitz et al. (1995)	N = 445 (multiple school districts within a state)	1st to 6th	Woodcock Johnson test
Sustaining Gap	Baker, Decker, and DeFries (1984)	N = 138 (two school districts)	Average age 9 and 15	7 different tests
	Juel (1988)	N = 54 (low SES area in a state)	1st to 4th	6 domains with multiple tests
	McGee, Williams, Share, Anderson, and Silva (1986)	N = 925 (Dunedin study sample)	Ages 5, 7,9 and 11	The Burt Wording Reading test
	Morgan, Farkas, and Hibel (2008)*	N = 10,587 (multistage cluster sample by nationwide)	Kindergarten to 3rd (5 times)	ECLS-K reading test
	Scarborough (1998)	N = 88 (one area of a state)	2rd and 8th	Woodcock Johnson test

* Indicates that these studies imposed latent growth modeling.