Literacy Patterns across Kentucky

Final Grant Report for the Collaborative Center for Literacy Development

Submitted by

Jill L. Adelson, Ph.D., and Emily R. Dickinson

University of Louisville

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Jill L. Adelson, Ph.D., & Emily R. Dickinson

Executive Summary

In 2009, the Collaborative Center for Literacy Development (CCLD) published a research agenda for Kentucky, asserting that "literacy remains a serious problem for many Kentuckians." (p. 3). Before policy makers, practitioners, and researchers can begin improving literacy in Kentucky, the nature and extent of the differences in literacy across different subgroups in the state must be examined. Based on sociocultural theory and prior research on subgroup differences, this study was designed to help policy makers and practitioners become more aware of the specific issues related to literacy achievement in the state by answering two general research questions (RQ):

RQ 1*: What are the patterns of student literacy achievement in Kentucky?*

RQ 2*: What is the relationship between literacy and mathematics achievement?*

With this understanding, Kentucky policy makers and practitioners can target literacy efforts and research to ensure greater achievement and attainment for *all* students in all schools across all districts.

This study used Hierarchical Linear Modeling (HLM) and Structural Equation Modeling (SEM) techniques to examine reaching achievement on the statewide achievement tests from 2007 to 2010 for all public school students in non-alternative education schools. Sample sizes ranged from 37,503 to 46,297 students, 203 to 660 schools, and 139 to 221 districts.

For RQ 1, we found that most of the variability in reading achievement is between students within the same school and district. The results illustrate that a student's prior reading achievement explains the greatest proportion of variability in a given year's reading achievement but that other student characteristics do have a statistically significant effect on reading achievement. In particular, students who are Black, are English Language Learners, or who qualify for free or reduced lunch have, on average, lower reading achievement scores. At the school-level, a school's proportion of students receiving free or reduced lunch also tends to have a negative relationship with students' reading scores, though this relationship was not consistently statistically significant. Other school and district characteristics were not consistently statistically significantly related to student reading achievement. In general, there was still a statistically significant amount of variation in student, school, and district achievement that could be explained by other variables not included in these models.

For RQ 2, we found that after controlling for student, school, and district characteristics related to mathematics achievement, students' reading achievement had a positive relationship with their mathematics achievement; students who score highly on one test tended to score highly on the other. This effect appeared to be mitigated somewhat by a student's sex, as the effect of reading achievement on mathematics achievement was lower for females than for males. The effect of reading achievement on mathematics achievement was also slightly lower for minority students than for White students, but again the magnitude of the effect is small. School and district characteristics added little or nothing to the explanation of variance between schools and districts in the effect of reading achievement on mathematics achievement.

The results presented in this report show that student characteristics, more so than school or district characteristics, have a strong relationship to student literacy, as well as to the relationship between mathematics and reading achievement. In all analyses, the majority of variance to be explained was between students, and student characteristics explained more variability at each level than school and district characteristics. Based on these results, recommendations include a focus for programming and research on students rather than on schools or districts, with particular attention given to students' prior achievement.

Abstract

This report explores patterns of literacy achievement in Kentucky, taking into account the role that student, school, and district characteristics may play in predicting student performance. Using Hierarchical Linear Modeling (HLM) and Structural Equation Modeling (SEM) techniques, the analyses show that student achievement varies most at the student level, that students' prior achievement is the greatest predictor of current year scores, and that reading achievement is positively related to achievement in mathematics. Based on these findings, it is recommended that future literacy research and interventions are focused on students rather than on schools or districts.

Introduction

In 2009, the Collaborative Center for Literacy Development (CCLD) published a research agenda for Kentucky, asserting that "literacy remains a serious problem for many Kentuckians." (p. 3). Before policy makers, practitioners, and researchers can begin improving literacy in Kentucky, the nature and extent of the differences in literacy across different subgroups in the state must be examined. The focus of this study was on providing more answers to the overarching CCLD question of "What do we know about Kentuckians' literacy achievement/attainment?" This study was designed to help policy makers and practitioners become more aware of the specific issues related to literacy achievement in the state by answering two general research questions, corresponding to CCLD's research questions 3 and 11:

> ***Research Question 1****: What are the patterns of student literacy achievement in Kentucky?*
>
> ***Research Question 2****: What is the relationship between literacy achievement and mathematics achievement?*

With this understanding, Kentucky policy makers and practitioners can target literacy efforts and research to ensure greater achievement and attainment for *all* students in all schools across all districts.

This report presents a theoretical framework to support our approach to the research and a review of relevant literature, followed by a description of the data used and the methodology employed. The results are presented in separate sections by research question. Finally, the discussion section summarizes the results for both research questions, and then we make recommendations based on the results.

Theoretical Framework and Literature Review

Reading Achievement in the United States

According to the National Center for Education Statistics (NCES, 2010), National Assessment for Educational Progress (NAEP) reading achievement of the country's fourth graders has changed little from 2007 to 2009. Reading achievement scores in 2009 were not statistically significantly different from scores in 2007 for any subgroup of fourth graders (race/ethnicity, sex, or type of school). Unfortunately, the nation has been holding steady at only one-third of fourth graders scoring at or above the *Proficient* level. Additionally, gaps between Whites and Blacks, Whites and Hispanics, females and males, and private and public schools remained steady during those years. In fact, the only gap that has narrowed since 1992 is between Whites and Blacks.

On the other hand, from 2007-2009, eighth-grade scores increased for students of all ethnicities, for males, and for public school students, although they were not different for females or private school students (NCES, 2010). Despite this increase (with an accompanying one percentage point per year in students at the *Proficient* level or above), only 35% of the nation's eighth graders scored at least at the *Proficient* level in 2009. Similar to fourth-grade scores, the eighth-grade scores did not exhibit any change in the existing achievement gaps. Since 1992, the only gap in eighth-grade scores that has narrowed has been the female-male gap.

Reading Achievement in Kentucky

Kentucky's average NAEP reading scores increased from 2007 to 2009, a trend observed in no other state or jurisdiction (NCES, 2010). However, while Kentucky students scored higher overall in 2009, there were not statistically significant increases in reading achievement from 2007 to 2009 for any subgroup except those eligible for free/reduced lunch (NCES, 2010).

Similar to the national trend, only 36% of Kentucky fourth graders scored at the *Proficient* level or above in 2009. In eighth-grade, Kentucky students increased scores from 2007 to 2009 for every race/ethnicity, sex, and free/reduced lunch eligibility subgroup except Black students[1]. Despite these gains, only 34% of Kentucky eighth graders (a smaller percentage than in the nation) scored at the *Proficient* level or above in 2009.

This lack of proficiency seen in the NAEP literacy assessments is mirrored by the percentage of Kentucky public schools making Adequate Yearly Progress (AYP). In the past three school years, the percent of Kentucky public schools making AYP has steadily decreased from almost 73% to the most recent report of 55% (Warren & Johnson, 2010). Despite this overall decrease in schools making AYP, student achievement levels varied across the state and across grade levels. For example, seven Kentucky elementary schools had every student reach *Proficient* or better in reading, mathematics, or social studies, and five of those schools were in Eastern Kentucky (Warren & Johnson, 2010). In terms of meeting proficiency goals, while 60% of the state's elementary schools are on track to meet goals by 2014, only 39% of middle schools are, and a mere 6% of high schools are (The Associated Press, 2010).

Sociocultural Theory

The various educational environments and expectations at each grade level, in each school, in each district, and across the many subgroups provide students across the state with differing cultural settings. According to Vygotsky's (1978, 1987) sociocultural theory, the different cultural settings that students experience affect their development. As shown in Figure 1, we considered individual student background characteristics, the school environment, and the district environment when examining patterns of literacy across Kentucky.

[1] Reporting standards for Hispanic and Asian/Pacific Islander students were not met in the state of Kentucky, so data on changes for those subgroups are not available.

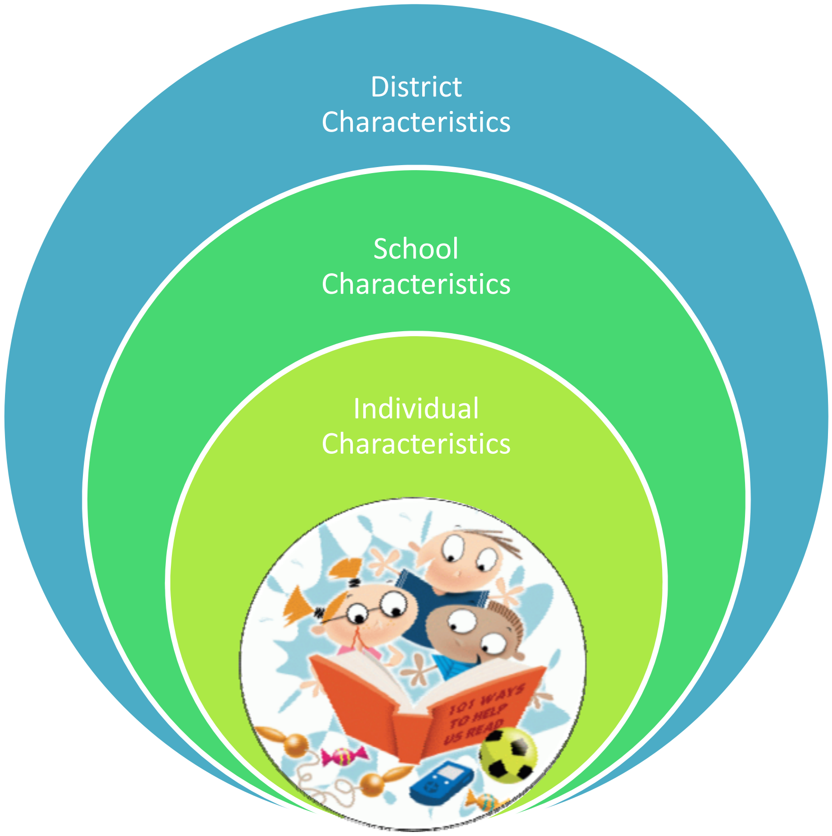

Figure 1. The sociocultural context surrounding Kentucky students' reading achievement includes individual student background characteristics, the school environment, and the district environment. Examining differences at all three levels is critical when examining patterns of literacy across Kentucky.

Subgroup Differences in Reading Achievement

Research has suggested differing conclusions regarding whether achievement score differences vary more *across* schools or *within* schools (Chiu & McBride-Change, 2006; Snow, Burns, & Griffin, 1998). Thus, looking at variables at both levels is important.

Sex differences in literacy achievement across cultures have been researched for several decades. Studies as far back as the 1970s have shown that females have traditionally experienced higher reading achievement than males (Klein, 1977). A decade ago, Gambell

(1999) found sex differences in overall reading scores favoring females across 32 nations and schools, and these findings were corroborated this decade by Chiu and McBride-Change (2006), who found that in all 43 countries in their study, female adolescents scored higher than their male schoolmates on reading achievement tests.

Numerous studies have shown disparities in reading achievement for minority students (e.g., Johnson, Flicker, & Lichtenberg, 2006 ; O'Bryant, Schrimster, & O'Jile, 2005). In fact, White-Black and White-Hispanic gaps have been found across all grade levels (e.g., Chatterji, 2006; Ingles, Burns, Chen, Cataldi, & Charleston, 2005; Reardon & Galindo, 2009). The NAEP results indicate that there has been little change in these gaps across the country in the last two decades. However, NAEP does not report on the achievement of Hispanics in Kentucky.

Across the decades, research has shown that students from families of higher SES typically achieve higher academically (Bradley & Corwin, 2002; Chiu, 2006; Coleman, 1988; Danziger, 1995; Duncan & Brooks-Gunn, 1997, McLoyd, 1998). Similarly, studies have shown that students in richer schools tend to outperform those in poorer schools (Snow et al., 1998).

Research on school size has shown inconsistent results. For instance, Fowler and Walberg (1996) found that school size was one of the most consistent predictors of achievement in New Jersey high schools. However, around the same time, Lamdin (1995) found that school size had a negligible effect on student achievement in Baltimore elementary schools.

The Relationship between Reading and Mathematics Achievement

Students' literacy has important consequences for achievement in other content areas, including mathematics. Lewis and Mayer (1987) differentiated a student's ability to comprehend a mathematics problem from the ability to solve the problem and noted that mathematics instruction tends to emphasize how to solve problems using mathematical computation rather than how to decipher the language used in mathematics problems. Students who fail to comprehend what a mathematics problem is asking them to do might fail to apply a computational technique that they have otherwise mastered. Similarly, Clarkson and Williams (1994) discussed how the wording and structure of mathematics word problems affected students' ability to comprehend and ultimately solve the problems.

Research has found moderate, positive correlations between Kentucky Core Content Test (KCCT) reading and mathematics scores at the high school level (Bacci, Koger, Hoffman, & Thacker, 2003). Prior to 2007, Kentucky administered mathematics and reading once during the elementary and middle school grade spans. Because KCCT has been expanded to include reading and mathematics tests at all grade levels 3-8 as well as once in high school, it is now possible to take a closer look at the relationship between reading and mathematics within grade levels and across years. Moreover, the question remains as to how this relationship varies across subgroups.

Methods

Participants and Data

The Kentucky Department of Education's (KDOE) Office of Assessment and Accountability provided the data for this study. We analyzed data from all students in public, non-alternative schools who took the assessments (tested grade levels were 3 through 8 for both subjects, 10 for reading, and 11 for mathematics). To determine whether there were trends or cohort effects, data from 2007 to 2010 were analyzed, which included the two most recent years of NAEP assessments and went through the most recent school year. KDOE provided student reading and mathematics scale scores from the state accountability assessment (range = 0 to 80) that were linked from year to year by a student identification code. Additionally, each student each year was linked to the school attended, and each school was linked to its district.

KDOE provided a number of variables describing the students, the schools, and their districts. As shown in Table 1, we chose variables based on prior research and CCLD's research agenda.

Table 1

Variables Included in the Analyses

Student-level	School-level	District-level
Sex	Enrollment size	Enrollment size
Race/ethnicity	% minority	% minority
Free/reduced lunch status	% free/reduced lunch	% free/reduced lunch
Special needs status (IEP)	Title I status	Region
ELL status	School-mean prior achievement	District-mean prior achievement
Prior achievement		

Table 2 presents the sample sizes for each grade level from each year. Sample sizes ranged from 37,503 to 46,297 students, 203 to 660 schools, and 139 to 221 districts.

Table 2

Sample Sizes for Each Grade Level and Year

	Students				Schools				Districts			
	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Grade 3	42,879	43,266	44,516	40,450	644	642	650	583	161	159	162	139
Grade 4	43,486	40,851	41,869	38,806	656	653	660	591	168	165	168	144
Grade 5	43,488	40,148	41,557	38,037	651	647	653	585	167	164	166	143
Grade 6	44,360	39,864	39,313	37,907	374	372	368	344	163	161	162	140
Grade 7	43,995	41,638	41,495	37,689	295	294	296	269	161	162	164	143
Grade 8	44,552	41,617	41,533	37,805	294	294	295	268	161	162	163	143
Grade 10	46,297	45,128	37,994	37,503	221	215	216	203	144	139	154	144

Table 3 presents descriptive statistics for the sample on student characteristics. On average, Kentucky had nearly equal proportions of males and females, and the majority of its students were White. With the exception of grade 10, a larger proportion of students received free or reduced lunch than not. Across the grade levels, there was on average between approximately 9% and 15% of students identified as having special learning needs and between 1% and 2.5% identified as English Language Learners.

Table 4 presents descriptive statistics for the sample on school- and district-level variables. The majority of Kentucky schools were identified as Title I schools. Schools were fairly evenly distributed across the geographic regions, with the exception of region 3, which is made up of a single, large urban district. School and district enrollments and proportion of minority and free/reduced lunch students was similar across the grade levels, with the notable exception of district enrollment in grade 10.

Table 3

Characteristics and Average Current and Prior Year Reading Scores (Averaged From 2007-2010) for Students

	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 10
Female	49.0	49.0	48.7	49.2	48.7	49.0	49.7
Asian	1.0	1.0	1.0	1.0	1.0	1.0	1.3
Black	10.7	10.2	10.2	10.0	10.0	10.0	10.5
Hispanic	3.2	2.7	2.5	2.2	2.2	2.0	2.3
Indian	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Other (Non-White)	2.2	2.0	2.0	1.7	1.7	1.5	1.3
White	82.5	83.8	84.0	85.0	85.3	85.5	86.8
Free/Reduced lunch	55.5	54.7	54.2	52.2	52.2	50.4	46.7
Special needs	15.3	14.0	13.3	12.0	11.5	11.3	9.5
ELL	2.5	1.8	1.5	1.0	1.0	1.0	1.0
Reading scale score	353.5	52.4	50.4	49.9	47.5	48.0	45.1
Prior reading scale score	NA	53.9*	51.8*	50.4*	49.7*	47.7*	48.9*
Mathematics scale score	353.1	51.3	47.9	46.1	45.1	42.1	37.7^
Prior mathematics scale score	NA	52.9*	50.5*	46.7*	45.9*	44.6	43.7^

*Averaged from 2008 to 2010 because 2006 data could not be linked to 2007 data.
^Mathematics scores from 11th grade; Data available only for 2010

Table 4

Distribution of School and District Characteristics (Averaged From 2007-2010)

	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 10
Average Proportions							
Non-Title 1 School	11.0	11.0	11.0	20.0	27.7	28.0	27.3
District Region 1	13.7	14.0	14.0	14.4	14.2	14.2	11.8
District Region 2	16.6	17.0	16.3	16.3	16.5	16.5	14.0
District Region 3	1.0	1.0	1.0	1.0	1.0	1.0	9.7
District Region 4	14.3	14.8	15.0	14.3	14.0	14.0	14.7
District Region 5	14.0	14.0	14.0	14.0	14.0	14.0	13.2
District Region 6	17.3	17.1	17.1	16.6	17.1	17.1	14.0
District Region 7	12.5	12.5	12.5	12.7	12.5	12.5	10.5
District Region 8	9.4	9.2	9.2	9.4	9.7	9.7	11.2
Average Means							
School % minority	15.2	15.2	15.0	10.0	11.5	11.5	12.0
School % free/reduced lunch	65.4	65.1	65.1	64.7	63.3	63.3	57.0
School enrollment	445.4	445.4	445.6	486.7	532.0	533.3	886.1
District % minority	8.7	8.7	10.2	8.7	9.0	10.0	13.0
District % free/reduced lunch	62.4	62.1	62.4	62.4	62.4	62.4	61.3
District enrollment	4,118	4042	3,934	4,068	4,050	4,049	3,954

Analyses

The data for this study had a hierarchical structure, with students nested within schools and schools nested within districts. This violates the assumption of independence of observations that most traditional statistics make. Therefore, hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) was used. According to McCoach and Adelson (2010), the use of HLM results not only allows more accurate Type I error rates[2] due to the standard errors taking into account clustered data but also allows (a) the variance to be portioned across levels of analysis so that variability between students within schools, between schools within districts, and between districts can be examined and (b) the examination of interactions and correlations among variables that occur at multiple levels of a hierarchy. Therefore, using HLM, we could appropriately model student-level outcomes (achievement) and also appropriately include school- and district-level variables predicting those outcomes without having to aggregate them.

To examine the patterns of literacy in Kentucky, we began each analysis with a three-level HLM, with students nested in schools nested in districts. The general analytic strategy followed the guidelines suggested by Raudenbush and Bryk (2002). For each analysis, we conducted a series of HLMs. First, we began by estimating an unconditional model and calculating the proportion of variance between students within schools, between schools within districts, and between districts. Then, we proceeded to build models based on theory separately for each grade level and each year. The outcome variables were the KCCT scores for that year and grade level. The student-level demographic variables as well as the previous years' achievement scores were entered into the equation at Level 1. School-level variables were entered at Level 2, and district-level variables will be entered at Level 3. At all levels of the

[2] An example of a Type I error is when a statistically significant difference between two groups or a statistically significant effect of one variable on another is found when in actuality there is no difference or effect.

analyses, categorical variables were dummy coded and continuous variables without a meaningful zero were grand-mean centered. The general model was as follows:

$$Y_{ijk} = \gamma_{000} + \sum_{a=1}^{d} \gamma_{00a} D_{ak} + \sum_{b=1}^{s} \gamma_{0b0} S_{bj} + \sum_{f=1}^{c} \gamma_{f00} C_{fi} + \mathrm{u}_k + \mathrm{r}_{jk} + e_{ijk}$$

where

Y_{ijk} was the Kentucky Core Content Test (KCCT) score for student *i* in school *j* in district *k*;

D, with *a* = 1 to *d* (the number of district-level variables) were the district-level variables;

S, with *b* = 1 to *s* (the number of school-level variables) were the school-level variables;

C, with *f* = 1 to *c* (the number of student-level variables) were the student-level variables;

$\mathbf{u}_k$ represents the incremental effect of district *k* on the observed outcome for each randomly-varying school-level variable;

$\mathbf{r}_{jk}$ represents the incremental effect of school *j* in district *k* on the observed outcome for each randomly-varying student-level variable; and

$\mathbf{e}_{ijk}$ represents the incremental effect of student *i* in school *j* in district *k*.

This model allowed for examination of patterns of achievement at each grade level across multiple years for a number of student-, school-, and district-level demographic variables while controlling for the other variables in the model. When examining these models, we also calculated the proportion of variance explained at each level by the variables.

For the first research question, regarding patterns of literacy achievement, KCCT reading score was the outcome. Mathematics scores were not included in the model.

To test the relationship between literacy and mathematics achievement, the second research question, mathematics achievement was the outcome variable. We included the prior years' mathematics achievement as a control variable and included statistically significant student, school, and district characteristics as predictors of mathematics achievement to appropriately model the intercept. Then, we added reading achievement scores to the model to determine what proportion of the variability in mathematics achievement was explained by reading achievement, above and beyond prior mathematics achievement and student, school, and district characteristics. We also tested interactions with reading achievement to see if the variables at any of the three levels (e.g., sex, minority status, Title I school) moderated the relationship between reading and mathematics achievement.

Results

Research Question 1

Table 5 presents the amount of variation in reading achievement that is between students within schools, between schools within districts, and between districts. Across all grade levels, the majority of variance in student reading achievement is between students (88%-92%), while an average of 7% to 9% of variance is between schools within districts and between 1% and 2% is between districts.

Table 5

Average Intra-Class Correlations 2007-2010

	Between students		Between schools		Between districts	
	Mean	SD	Mean	SD	Mean	SD
Grade 3	.90	0.003	.09	0.001	.02	0.002
Grade 4	.89	0.003	.09	0.002	.02	0.001
Grade 5	.88	0.008	.09	0.005	.02	0.004
Grade 6	.91	0.002	.07	0.001	.02	0.002
Grade 7	.91	0.008	.08	0.006	.01	0.004
Grade 8	.91	0.011	.08	0.006	.02	0.008
Grade 10*	.92	0.005	.08	0.005	NA	NA

*Because several districts had only one high school and there was not statistically significant variability in achievement at the district level, grade 10 was modeled as a 2-level model.

Tables 6 through 8 present the effects of the student-level variables on reading achievement. A student's prior achievement in reading had a positive and statistically significant effect on current year reading achievement; each 1-unit increase in prior year reading score is associated with a 0.61- to 0.71-unit increase in current year reading score, across grade levels and years. Other student-level effects that were statistically significant across grades and years were whether or not a student was female (effects ranging from 1.44 to 6.71), Black (-0.56 to -8.01), or Asian (1.17 to 6.88) and whether the student received free or reduced lunch (-2.08 to -8.24). It is important to note that the coefficients from 2007 tend to be the largest in magnitude, likely a reflection of not being able to control for prior achievement because KDOE did not use consistent identifiers to link student data from 2006 to later years. Other student variables were not consistently statistically significant. In general, effects of being Indian or other race were not statistically significant, likely a reflection of their small proportion of the student population in Kentucky. Though not significant in some instances, the effects of ELL and special needs status were consistently negative. The effect of being Hispanic was inconsistent in both statistical significance and direction across grades and years but was more often positive. This could be a reflection of controlling for ELL status; once language proficiency was accounted for, being Hispanic often had a positive effect on reading achievement.

With the exception of schools' proportion of free or reduced lunch students, school- and district-level effects tended to be non-significant, though none of the higher-level effects were consistent across grades and years in terms of direction and statistical significance. Because of the lack of significant effects, the remainder of this section will focus on the proportion of variance explained by the models rather than the magnitude and direction of the effects.

Table 6

Student-Level Results: Elementary School

	Grade 3				Grade 4				Grade 5			
	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Prior achievement	NA	NA	NA	NA	NA	0.63	0.63	0.63	NA	0.69	0.69	0.67
Female	1.55	3.39	2.43	2.82	4.44	3.90	2.27	3.39	4.41	3.51	2.80	3.31
ELL	-8.10	-5.07	-8.20	-8.96	-7.10	-0.63	-1.89	-0.57	-9.53	-2.46	-3.09	-3.45
IEP	-8.52	-8.04	-8.09	-8.00	-7.80	-0.32	-1.91	-1.52	-9.59	-3.97	-4.68	-3.41
Free/Reduced lunch	-8.24	-7.55	-7.67	-7.50	-7.51	-2.59	-3.39	-2.60	-7.66	-2.72	-3.08	-2.30
Black	-8.01	-6.71	-7.30	-7.14	-7.32	-1.66	-2.62	-1.55	-6.45	-1.90	-1.17	-0.75
Hispanic	1.10	-0.69	0.86	1.16	2.31	0.58	0.93	1.36	1.87	-0.46	1.17	2.21
Asian	3.00	2.12	4.45	2.67	4.74	2.18	3.85	1.80	6.12	2.67	2.83	3.64
Indian	0.51	-0.22	0.54	-6.75	1.24	-1.90	-1.18	-1.46	-3.00	-1.65	0.50	-0.97
Other	-2.75	-0.88	-0.83	-1.56	-0.78	-0.24	-0.41	-0.24	-0.76	-0.04	0.23	0.69

Note. Shaded cells reflect non-significant values ($p < .05$). 2007 results are not controlling for prior achievement because KDOE did not use consistent identifiers to link student data from 2006 to later years. Grade 3 results are not controlling for prior achievement because students are not tested prior to that grade.

Table 7

Student-Level Results: Middle School

	Grade 6				Grade 7				Grade 8			
	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Prior ach.	NA	0.69	0.69	0.67	NA	0.65	0.65	0.61	NA	0.69	0.71	0.67
Female	5.85	3.70	3.72	3.27	6.45	2.55	2.39	2.82	6.71	1.75	2.46	2.55
ELL	-14.85	-5.20	-5.11	-5.58	-11.91	-0.78	-2.77	-1.81	-11.34	-3.16	-2.73	-2.34
IEP	-12.77	-5.96	-6.02	-5.37	-12.86	-3.28	-3.54	-3.62	-13.28	-3.75	-4.27	-4.18
Free/Red. lunch	-7.69	-3.17	-3.19	-3.64	-7.16	-2.25	-2.66	-2.61	-6.77	-2.29	-2.63	-2.43
Black	-5.82	-2.17	-2.11	-2.48	-4.96	-0.56	-1.39	-1.15	-4.02	-1.52	-1.56	-1.30
Hispanic	1.95	0.22	0.21	0.98	1.29	1.19	2.06	1.26	1.22	0.65	0.85	0.98
Asian	5.13	2.92	3.13	3.15	6.49	3.15	4.17	3.81	6.88	3.19	3.24	3.29
Indian	-0.23	0.02	-0.58	0.48	0.56	-1.25	-1.40	-3.68	-1.54	-0.92	1.21	0.17
Other	-0.20	0.40	0.51	-0.67	-0.02	0.18	0.13	0.96	-0.18	-0.48	-0.22	0.13

Note. Shaded cells reflect non-significant values ($p < .05$). 2007 results are not controlling for prior achievement because KDOE did not use consistent identifiers to link student data from 2006 to later years.

Table 8

Student-Level Results: High School (Grade 10)

	2007	2008	2009	2010
Prior achievement (Grade 8)	NA	NA	0.61	0.65
Female	5.94	5.24	1.44	1.56
ELL	-12.76	-15.67	-3.28	-3.02
IEP	-13.91	-14.56	-6.27	-5.30
Free/Reduced lunch	-5.88	-5.91	-2.08	-2.45
Black	-5.45	-5.58	-1.44	-1.54
Hispanic	-0.42	0.07	0.12	-0.12
Asian	3.85	5.22	2.37	1.17
Indian	0.03	1.51	0.00	-0.59
Other	-0.57	-1.46	0.15	-0.10

Note. Shaded cells reflect non-significant values ($p < .05$). 2007 and 2008 results are not controlling for prior achievement because KDOE did not use consistent identifiers to link student data from 2006 to later years.

Tables 9 and 10 present the proportion of variance in reading achievement between students within schools, between schools within districts, and between districts that was explained by students' prior achievement, other student characteristics, school characteristics, and district characteristics. Statistics for 2007 are presented separately in Table 9 because we were unable to account for prior achievement that year and thus the proportion of variance explained was markedly different, especially by student characteristics. Without controlling for prior achievement, student characteristics accounted for between 10% and 21% of variance in reading achievement between students, between 24% and 36% between schools, and between 0% and 16% between districts. Without controlling for prior achievement, school characteristics explain between 8% and 25% of between school variance and essentially none of the variance between districts. District characteristics explain between 25% and 64% of the variance between districts in the model that does not control for students' prior achievement.

Table 10 presents average proportions of variance explained for 2008 through 2010. Students' prior achievement explains the largest proportion of variance in reading achievement, ranging from 44% to 53% between students on average, 48% to 72% between schools on average, and 55% to 60% between districts on average. Student demographics add little more to explain between-student and between-school variance, 3% to 6% and 2% to 6%, on average. Student characteristics explain a higher proportion of between-district variance, ranging from an average of 0% to 14%. School characteristics explain, on average across years, between 2% and 11% of between-school variance and between 0% and 12% of between-district variance beyond what was explained by student characteristics. Finally, the district-level variables explain between 7% and 48% of the between-district variance, on average.

Table 9

Proportion of Variance Explained by Student, School, and District Characteristics: 2007

	Between student	Between school	Between district
Student Characteristics			
Grade 4	.10	.25	0
Grade 5	.13	.30	.11
Grade 6	.18	.34	.16
Grade 7	.20	.36	0
Grade 8	.20	.31	.05
Grade 10*	.21	.24	NA
School characteristics			
Grade 4		.14	0
Grade 5		.19	0
Grade 6		.16	0
Grade 7		.25	0
Grade 8		.29	0
Grade 10*		.08	NA
District characteristics			
Grade 4			.33
Grade 5			.30
Grade 6			.25
Grade 7			.42
Grade 8			.64
Grade 10*			NA

*Because several districts had only one high school, Grade 10 was modeled as a 2-level model.
Note. These results are not controlling for prior achievement because KDOE did not use consistent identifiers to link student data from 2006 to later years.

Table 10

Average Proportion of Variance Explained by Student, School, and District Characteristics 2008-2010

	Between student		Between school		Between district	
	Mean	SD	Mean	SD	Mean	SD
Student prior achievement						
Grade 4	.44	.001	.48	.042	.58	.065
Grade 5	.45	.020	.51	.040	.60	.090
Grade 6	.47	.017	.50	.008	.60	.033
Grade 7	.50	.005	.58	.015	.60	.064
Grade 8	.53	.009	.72	.031	.55	.132
Grade 10*^	.48	.013	.55	.033	NA	NA
Student characteristics (above and beyond prior achievement)						
Grade 4	.03	.002	.02	.021	.09	.015
Grade 5	.04	.004	.04	.020	.08	.059
Grade 6	.06	.005	.05	.055	.14	.075
Grade 7	.04	.006	.06	.027	0	.188
Grade 8	.04	.006	.04	.049	.08	.110
Grade 10*^	.05	.003	.02	.022	NA	NA
School characteristics						
Grade 4			.04	.019	0	.259
Grade 5			.02	.017	.12	.138
Grade 6			.02	.030	.12	.122
Grade 7			.09	.054	0	.413
Grade 8			.11	.069	.06	.099
Grade 10*^			.08	.038	NA	NA
District characteristics						
Grade 4					.17	.056
Grade 5					.37	.040
Grade 6					.29	.217
Grade 7					.48	.057
Grade 8					.17	.070
Grade 10*^					NA	NA

*Because several districts had only one high school, Grade 10 was modeled as a 2-level model.
^Grade 10 average from 2009-2010 because prior year achievement not available for 2008 because KDOE did not use consistent identifiers to link student data from 2006 to later years.

Research Question 2

Preliminary analyses. Before conducting the HLM analyses, we first conducted preliminary multilevel structural equation modeling (ML-SEM) analyses to examine the extent to which reading and mathematics achievement are related. To account for measurement error in the achievement tests, we created two latent constructs – reading achievement and mathematics achievement, each of which was measured by three years of achievement scores in the content area. We conducted this analysis with students who were in third grade in 2008, fourth grade in 2009, and fifth grade in 2010 and in the same school each year they were tested in Kentucky. This allowed us to model elementary school achievement and account for school attended. Similarly, we conducted this analysis with students who were in sixth grade in 2008, seventh grade in 2009, and eighth grade in 2010 and in the same school each year they were tested in Kentucky. This allowed us to model middle school achievement and account for school attended. As shown in Figure 2, we allowed the errors within a year to correlate, reflecting that those measures were obtained at the same time and may have been affected by similar influences outside student achievement/ability.

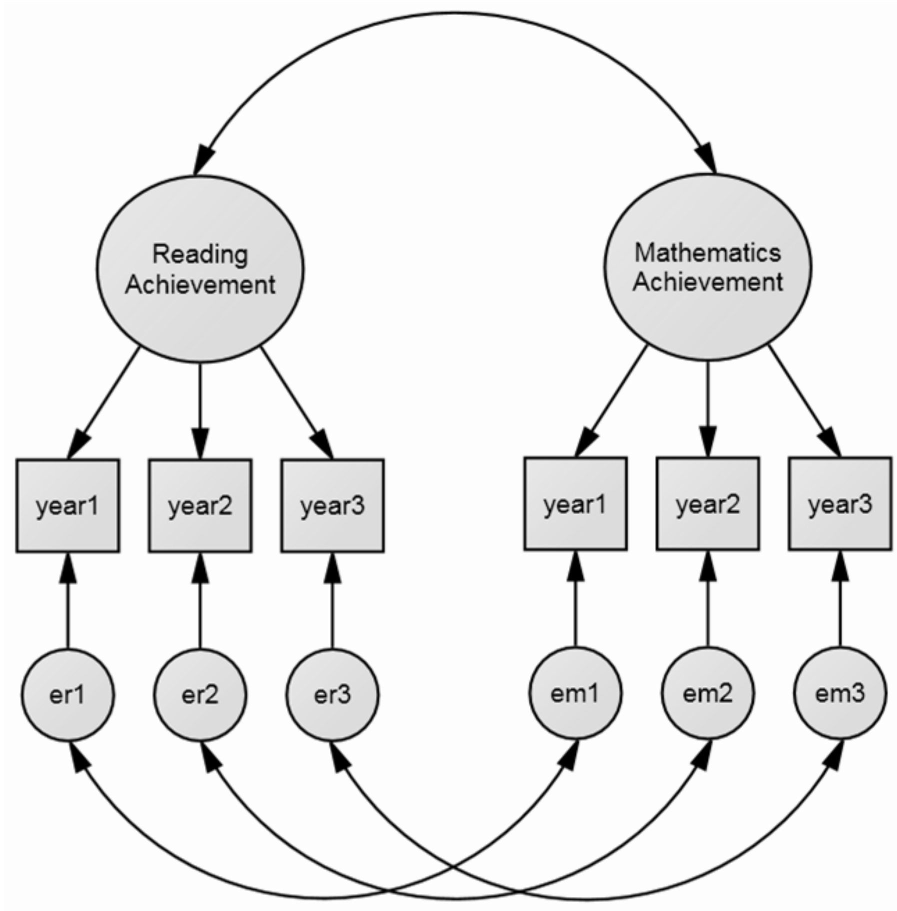

Figure 2. Model to examine the relationship between reading and mathematics achievement in elementary students (year 1 = grade 3, 2008; year 2 = grade 4, 2009; year 3 = grade 5, 2010) and in middle school students (year 1 = grade 6, 2008; years 2 = grade 7, 2009; year 3 = grade 8, 2010).

At the elementary school level, there were 35,245 students who remained in the same school during the years they were tested in Kentucky. Those students were nested in 771 schools, with an average of about 46 students per school, and between 11.5% and 15.9% of the variability in the achievement measures were between schools (with the majority being between students within schools). Because we used maximum likelihood, students who were not tested in Kentucky for any of the measurements were still included in the model. 93% of students had third-grade data, 95% had fourth-grade data, and 89% had fifth-grade data. The model fit the data extremely well $CFI = 1.000$, $TLI = 0.999$, $RMSEA = 0.008$, $SRMR_{within} = 0.003$, $SRMR_{between}$

= 0.007). Reading achievement and mathematics achievement were strongly correlated at the student level, *r* = .864 ($p < .001$). School-level reading and mathematics achievement were even more strongly correlated, *r* = .932, $p < .001$). As shown in Table 11, the amount of variation explained in each achievement measurement (R^2) ranged from 60% to 77% at the student level and from 56% to 86% at the school level, indicating that there is substantial variability in achievement left to be explained beyond the construct of achievement/ability.

Table 11

Proportion of Variance Explained (R^2) *in Achievement Measures by Student Achievement Construct in Elementary School Model*

Level	Observed variable	R^2	S.E.	*p*
Within	Reading Grade 3	.598	0.006	< .001
	Reading Grade 4	.741	0.005	< .001
	Reading Grade 5	.626	0.006	< .001
	Mathematics Grade 3	.674	0.006	< .001
	Mathematics Grade 4	.772	0.005	< .001
	Mathematics Grade 5	.735	0.006	< .001
Between	Reading Grade 3	.674	0.040	< .001
	Reading Grade 4	.852	0.031	< .001
	Reading Grade 5	.628	0.036	< .001
	Mathematics Grade 3	.557	0.044	< .001
	Mathematics Grade 4	.862	0.037	< .001
	Mathematics Grade 5	.648	0.041	< .001

At the middle school level, there were 36,440 students who remained in the same school during the years they were tested in Kentucky. Those students were nested in 447 schools, with an average of about 82 students per school, and between 12.0% and 14.6% of the variability in the achievement measures were between schools (with the majority being between students within schools). Because we used maximum likelihood, students who were not tested in Kentucky for any of the measurements were still included in the model. 93% of students had sixth-grade data, 93% had seventh-grade data, and 75% had eighth-grade data. The model fit the data very well (*CFI* = 0.999, *TLI* = 0.997, *RMSEA* = 0.016, $SRMR_{\text{within}}$ = 0.005, $SRMR_{\text{between}}$ = 0.015). Reading achievement and mathematics achievement were strongly correlated at the student level, $r = .861(p < .001)$. School-level reading and mathematics achievement were even more strongly correlated, $r = .907$, $p < .001$). As shown in Table 12, the amount of variation explained in each achievement measurement (R^2) ranged from 69% to 83% at the student level and from 81% to 96% at the school level, with the great amount of variability being explained in seventh-grade achievement. These proportions indicate that there is variability in achievement left to be explained beyond the construct of achievement/ability, particularly at the student level, although not as much as at the elementary school level.

Table 12

Proportion of Variance Explained (R^2*) in Achievement Measures by Student Achievement Construct in Middle School Model*

Level	Observed variable	R^2	S.E.	*p*
Within	Reading Grade 6	.690	0.006	< .001
	Reading Grade 7	.745	0.006	< .001
	Reading Grade 8	.722	0.006	< .001
	Mathematics Grade 6	.751	0.006	< .001
	Mathematics Grade 7	.834	0.005	< .001
	Mathematics Grade 8	.793	0.006	< .001
Between	Reading Grade 6	.807	0.035	< .001
	Reading Grade 7	.942	0.018	< .001
	Reading Grade 8	.878	0.029	< .001
	Mathematics Grade 6	.824	0.034	< .001
	Mathematics Grade 7	.955	0.019	< .001
	Mathematics Grade 8	.868	0.028	< .001

Differences in the relationship between reading and mathematics achievement. Given the strong relationship between reading and mathematics achievement shown in the preliminary analyses, we next used HLM to conduct cross-sectional analyses of the data to examine differences in the relationship between reading and mathematics achievement. First, we analyzed a null model with no predictors to calculate the intra-class correlations. Then in a series of models we added student-level predictors, then school-level predictors, and finally district-level predictors of mathematics achievement, removing those that were not statistically significant at each step. This provided a model controlling for those characteristics. Table 13 presents average intra-class correlations from the null model as well as average proportions of variation in mathematics achievement between students within schools, between schools within districts, and between districts that were explained by control variables. Similar to the ranges of values observed for reading achievement, the proportion of between-student variance was approximately 87% to 92%, between-school variance was 8% to 11%, and between-district variance was between 2% and 3%. The proportion of between-student variance in mathematics achievement explained by the control variables ranged from 53% to 66%. The between-school proportion of variance explained ranged from 37% to 69%, and the between-district proportion of variance explained ranged from 60% to 84%.

Table 13

Average Intra-Class Correlations and Proportion of Variance Explained by Control Variables for 2008-2010: Mathematics Achievement

	Intra-class correlations						Proportion of variance explained					
	Between students		Between schools		Between districts		Between students		Between schools		Between districts	
Grade	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
4	.87	0.011	.11	0.003	.02	0.011	0.53	0.017	0.42	0.060	0.78	0.235
5	.87	0.008	.11	0.011	.02	0.003	0.56	0.010	0.51	0.027	0.68	0.199
6	.89	0.007	.08	0.003	.03	0.004	0.58	0.016	0.37	0.047	0.60	0.063
7	.89	0.004	.09	0.002	.02	0.005	0.61	0.006	0.57	0.061	0.84	0.158
8	.89	0.009	.09	0.007	.02	0.005	0.66	0.011	0.69	0.097	0.76	0.049
11*^	.92	NA	.08	NA	NA	NA	0.59	NA	0.49	NA	NA	NA

*Because several districts had only one high school and there was not statistically significant variability in achievement at the district level, Grade 11 was modeled as a 2-level model.
^Due to availability of prior mathematics achievement data, 2010 was the only year included for Grade 11.

Reading achievement scores were next entered into the model as predictors of mathematics achievement. Because reading and mathematics are not tested in the same grade at the high school level, prior year reading achievement was entered into the model for grade 11. Table 14 presents the coefficients and proportions of variance explained at each level by the reading model.

Table 14

Average Coefficient for the Reading Slope (Predicting Mathematics Achievement) and the Proportion of Variance in Mathematics Explained by Reading above and beyond Control Variables

	Coefficient		Proportion of variance explained					
			Between-student		Between-school		Between-district	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Grade 4	0.46	0.04	0.45	0.41	0.57	0.29	0.00	1.03
Grade 5	0.42	0.02	0.17	0.01	0.54	0.35	0.40	0.16
Grade 6	0.39	0.01	0.18	0.00	0.31	0.04	0.24	0.01
Grade 7	0.42	0.01	0.17	0.01	0.25	0.07	0.00	5.49
Grade 8	0.39	0.02	0.14	0.01	0.17	0.10	0.27	0.16
Grade 11*	0.42	NA	0.12	NA	0.17	NA	NA	NA

*Grade 11 mathematics is predicted from grade 10 reading

Table 14 shows a consistently positive and statistically significant relationship between reading achievement and mathematics achievement. As a student's reading achievement increases one unit, their mathematics achievement is expected to increase, on average, between 0.39 and 0.46 units, across the grade levels, after controlling for student-, school-, and district-level variables. Above and beyond the student, school, and district characteristics, adding reading to the model explains between 12% and 45% of the variance in mathematics achievement between students, with a great deal being explained in Grade 4 and a moderate amount being explained at other grade levels; between 17% and 57% of variance between schools, with a great deal being explained at the elementary school level and the least amount being explained at the Grade 8 and high school levels; and between 0% and 40% of variance between districts.

What is of greater interest for this report is whether or not there were differences in the effect of reading achievement on mathematics achievement among the various student subgroups. Tables 15 through 17 present the coefficients for the interactions between sex, minority status, and lunch status and reading. With the exception of Grade 4, the interaction between sex and reading is statistically significant. Across all the grade levels, the coefficients are negative, indicating that the effect of reading achievement on mathematics achievement is lower for females than for males. The interaction between lunch status and reading is not consistently statistically significant at any of the grade levels (with the exception of high school in which only one year is reported), nor is there consistency in the direction of the relationship. Though not consistently statistically significant across all grade levels, the interaction between minority and reading is consistently negative (with the exception of Grade 5 in 2008). With the exception of Grade 7 in 2009, the minority/reading interaction was statistically significant across the middle school grades. The negative coefficients can be interpreted as the effects of reading achievement on mathematics achievement being smaller for minority students than for white students.

Table 15

Student-Level Interactions: Elementary School

	Grade 4			Grade 5		
	2008	2009	2010	2008	2009	2010
Female*Reading	-0.014	-0.010	-0.012	-0.034	-0.039	-0.025
Free/Reduced lunch*Reading	0.020	0.009	0.014	0.022	-0.003	0.016
Minority*Reading	-0.006	-0.014	-0.027	0.002	-0.017	-0.021

Note. Shaded cells reflect non-significant values ($p < .05$).

Table 16

Student-Level Interactions: Middle School

	Grade 6			Grade 7			Grade8		
	2008	2009	2010	2008	2009	2010	2008	2009	2010
Female*RD	-0.038	-0.039	-0.042	-0.054	-0.026	-0.047	-0.045	-0.054	-0.033
Lunch*RD	0.007	0.008	0.002	-0.006	0.017	0.029	0.001	0.007	-0.022
Minority*RD	-0.023	-0.028	-0.022	-0.034	0.006	-0.053	-0.034	-0.031	-0.046

Note. Shaded cells reflect non-significant values ($p < .05$).

Table 17

Student-Level Interactions: High School (2010)

	Coefficient
Female*Reading	-0.083
Free/Reduced lunch*Reading	-0.069
Minority*Reading	-0.028

Note. Shaded cells reflect non-significant values (p < .05).

School- and district-level variables were subsequently added into the model as predictors of the effect of reading achievement on mathematics achievement. None of these variables had consistently statistically significant relationships with the reading-on-mathematics slope, and the majority of them were not statistically significant across grades and years. Also, for at least one year in each grade level (with the exception of Grade 11 in which only one year of data was available), there was no statistically significant amount of between-district variance in the reading-on-mathematics slope to be explained. The remainder of this results section will discuss the proportion of variance in the reading-on-mathematics slope explained by the student, school, and district characteristics included in these analyses.

Table 18 shows that essentially no between-student variance in the effects of reading achievement on mathematics achievement is accounted for by the interactions between sex, lunch, and minority statuses. These interactions explain between 0.3% and 5% of the variance in the reading-on-mathematics slope between schools and between approximately 0% and 18% of between-district variance in the effect of reading achievement on mathematics achievement. Similarly, school and district characteristics, with a couple of exceptions (Grade 6 and Grade 8 between district variance), explain on average essentially none of the variance between schools and districts in the effect of reading achievement on mathematics achievement.

Table 18

Average Proportion of Variance in Reading-on-Mathematics Slope Explained by Student, School, and District Characteristics 2008-2010

	Between student		Between school		Between district	
	Mean	SD	Mean	SD	Mean	SD
Student interactions						
Grade 4	0	5.556	0.05	0.012	0.09	0.124
Grade 5	0	0.005	0.05	0.042	0.05	0.037
Grade 6	0	0.000	0.04	0.018	0.03	0.087
Grade 7	0.01	0.007	0.05	0.034	0.18	0.220
Grade 8	0	0.006	0.05	0.050	0	0.632
Grade 11*^	0	NA	0.003	NA	NA	NA
School interactions						
Grade 4			0.02	0.044	0	0.207
Grade 5			0.03	0.024	0.02	0.058
Grade 6			0	0.027	0.31	0.072
Grade 7			0.04	0.049	0	0.435
Grade 8			0	0.059	0	0.133
Grade 11*^			0	NA	NA	NA
District interactions						
Grade 4					0	1.200
Grade 5					0	3.170
Grade 6					0	3.027
Grade 7					0	6.559
Grade 8					0.34	0.550
Grade 11*^					NA	NA

*Because several districts had only one high school and there was not statistically significant variability in achievement at the district level, Grade 11 was modeled as a 2-level model.
^Grade 11 based on 2010 only

Discussion and Recommendations

Discussion

The first research question explored literacy patterns in Kentucky. The results illustrate that a student's prior reading achievement explains the greatest proportion of variability in a given year's reading achievement but that other student characteristics do have a statistically significant effect on reading achievement. In particular, students who are Black, are English Language Learners, or who qualify for free or reduced lunch have, on average, lower reading achievement scores. At the school-level, a school's proportion of free or reduced lunch students also tends to have a negative relationship with students' reading scores, though this relationship was not consistently statistically significant. Other school and district characteristics were not consistently statistically significantly related to student achievement, but the combination of school- and district-level variables did add to the explanation of variance between schools and districts. In general, there was still a statistically significant amount of variation in student, school, and district achievement that could be explained by other variables not included in these models. Literacy experts should consider measuring other school and district characteristics that may be impacting student achievement for inclusion in future analyses. Koger et al. (2008) found differences between high-performing and low-performing Kentucky schools on such school-level factors as the focus on student-focused instruction and the implementation of professional learning communities. Data on such characteristics could be useful in shedding additional light on literacy patterns in Kentucky. In the meantime, these results support continued literacy interventions focused on student subgroups in Kentucky, particularly African American students, English Language Learners, and low-income students, as well as on schools with high proportions of low-income students.

The second research question explored the relationship between reading achievement and mathematics achievement in Kentucky. After controlling for student, school, and district characteristics related to mathematics achievement, students' reading achievement had a positive relationship with their mathematics achievement; students who score highly on one test tended to score highly on the other. This effect appeared to be mitigated somewhat by a student's sex, as the effect of reading achievement on mathematics achievement was lower for females than for males. The effect of reading achievement on mathematics achievement was also slightly lower for minority students than for White students, but again the magnitude of the effect is small. Student lunch status did not have a consistent effect on the effect of reading on mathematics. School and district characteristics added little or nothing to the explanation of variance between schools and districts in the effect of reading achievement on mathematics achievement.

The results presented in this report show that student characteristics, more so than school or district characteristics, have a strong relationship to student literacy, as well as to the relationship between mathematics and reading achievement. In all analyses, the majority of variance to be explained was between students, and student characteristics explained more variability at each level than school and district characteristics. As much of the accountability policy and resulting intervention practices are school-focused, these results raise questions about the appropriateness of such an approach. Students' prior reading achievement explained a large proportion (at some grade levels more than half) of the variance in student reading achievement at not only the student level but also at the school and district levels. This highlights the importance that all students are given opportunities to achieve at high levels early on in their educational experience; early achievement will be carried forward. Moreover, it suggests a "clientele" effect in which average school and district achievement explain a great deal of the variability between schools and districts. By focusing on the students' prior achievement rather than even the make-up of the school or district, policy makers and administrators can focus their funds, efforts, and interventions more at the heart of the strongest predictor of reading achievement. Beyond the importance of creating opportunities for early success in school, this report also highlights the need for continued interventions focused on the needs of African American, English language learner, and economically disadvantaged students.

This report also explores the relationship between literacy and mathematics in Kentucky. Students who achieved well in reading tended to achieve in mathematics as well. This relationship is slightly less strong for female and minority students, though sex and minority status do not completely mitigate the positive correlation between reading and mathematics scores. Although the variables included in these analyses explained extremely small proportions of the variability in the relationship between literacy and mathematics achievement, it does lay a foundation for subsequent research to do so. This report illustrates that student literacy has important implications for success in other content areas.

Recommendations

The following general and specific recommendations are made based on the findings presented in this report:

- Funding for both programming and research should be focused at the student level, rather than at the school or district levels.
- Efforts should be made to identify and properly serve at-risk students at all schools, regardless of how high performing the school or district in which they are enrolled.
- Student interventions should take into account student prior achievement, the strongest predictor of current-year achievement.

- Teachers need to be provided tools for diagnostic and formative assessment to identify students' literacy weaknesses and to measure growth throughout the year. This is critical given the strong connection between prior achievement and current achievement.
- There is a strong connection between reading achievement and mathematics achievement. As such, reading strategies should be integrated into mathematics classrooms. For students who have strong mathematics skills and weak literacy skills, this would allow them to address their weakness through their strength. Additionally, given the relationship, by strengthening their reading achievement, they may also increase their ability to do well in mathematics.

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