

Associations Between Reading and Mathematics Achievement in Ohio



An Analysis of Student State
Test Performance

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**Department of
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Table of Contents

EXECUTIVE SUMMARY.....2

RESEARCH AIMS3

METHODS3

RESULTS4

To what extent do students’ scores in third grade correlate with scores in later grades within each content area (English language arts and math)?.....4

To what extent do students’ grade 3 reading scores correlate to their later math scores, and vice versa?5

To what extent do these correlations differ for various subgroups of students?.....5

To what extent is the likelihood of achieving math proficiency associated with early reading skills?.....6

CONCLUSION7

REFERENCES.....8

Executive Summary

Gaining proficiency in reading and mathematics are arguably the two most important academic goals for young students. Even though very different types of skills must be taught to ensure proficiency in reading and math, respectively, research suggests that performance on measures of reading and math are highly and positively correlated.

There are several consistent findings from studies examining the connections between reading and math that may be important for policymakers to consider. **First**, research suggests that developmental paths in both reading and math appear to be determined in the early grades (Clements et al., 2016; Jordan et al., 2009; LeFevre et al., 2010). That is, students' early reading skills predict later reading skills (Cunningham & Stanovich, 1997); similarly, students' early math skills are associated with later math abilities (Rittle-Johnson et al., 2017; Siegler et al., 2012). **Second**, studies have shown that reading and math skills are strongly correlated. For example, research suggests that 30-70% of students with difficulties in either reading or math also experience difficulties in the other domain (Landerl & Moll, 2010). **Finally**, although there is mixed evidence regarding whether reading proficiency is causally related to math proficiency or vice versa, recent studies support the idea that strong reading skills may be a prerequisite for developing math skills (Erbelli et al., 2020; Grimm, 2008; Hübner et al., 2022).

This research brief utilizes state test scores to examine the extent to which third grade scores are correlated with reading and math scores in later grades, respectively, as well as the extent to which third grade scores in one domain (reading or math) are related to scores in later grades in the other domain. Although questions of causality cannot be addressed in this research, the probability of students achieving math proficiency in third grade based on their earlier grade reading performance is also examined.

Findings from these analyses revealed that:

- Third grade scores in reading and math are relatively consistent and highly correlated with later grade scores in reading and math, respectively. This was evident even when looking at correlations specific to different subgroups. The strength of correlations slightly declined over time but remained significant. This finding underscores the critical importance of effective instruction from school entry to ensure students are on a solid and positive developmental trajectory as early as possible.
- Reading and math scores are strongly correlated at concurrent timepoints but also longitudinally. The extent to which grade 3 scores correlate to scores in later grades wanes slightly over time but remains relatively strong and positive. As math concepts become more complex in later grades and tests assess narrower concepts, such as geometry and algebra, it is logical that early reading scores may be related to math outcomes but not as strongly as in previous grades. Overall, it seems likely that reading and math are related but separate skills that each require effective and evidence-based instruction throughout a student's academic career.

- Finally, when considering even earlier associations between reading and math, results show that kindergarten students whose fall reading diagnostic scores were *on track* for reading at grade level were 2.7 times more likely to be proficient in third grade math than their kindergarten peers who were *not on track* in reading. These odds progressively increased when considering first grade and second grade reading scores. This suggests not only that reading and math scores are correlated over time, but this relation is evident at the onset of formal education. As such, supporting language and literacy skills prior to kindergarten may serve as an advantage to students as they enter school.

Considered altogether, results from this research brief support the idea that reading and math are related but separate skillsets that each require effective and evidence-based instruction throughout a student's academic career. Further, these findings suggest not only that reading and math correlated over time, but that this relation is evident at the onset of formal education. As such, policies that support language and literacy skills prior to kindergarten may serve as an advantage to students as they enter school, and that continued strong instruction in English language arts is critical to ensure long-term academic success.

Research Aims

Although research studies consistently find that math and reading scores are highly correlated, both concurrently and in cross-lagged analyses, it is important to understand whether performance on state tests yields similar outcomes to those in more tightly controlled research studies.

- 1) To what extent do students' third grade reading scores correlate with scores in later grades? Similarly, to what extent do students' third grade math scores correlate with scores in later grades?
- 2) To what extent do students' reading scores correlate to their math scores, and vice versa?
- 3) To what extent do these correlations differ across student subgroups?
- 4) To what extent is the likelihood of third grade math proficiency associated with early reading skills prior to third grade?

Methods

All available data was obtained for students who took Ohio's State Tests for English Language Arts and Math from the 2016-2017 school year through the 2022-2023 school year. The number of students at each comparison point varied, ranging from more than 700,000 students who had taken both tests in third grade to just over 3,000 students who had a third grade English language arts test and a high school math test. This is because most students in this dataset who were in third grade in the 2016-2017 school year would not yet have taken the high school English language arts test by the 2022-2023 school year.

Analyses were conducted first at the full sample level and then separately for each demographic subgroup, as well as for students receiving reading support. Scaled scores from Ohio's State Tests for English Language Arts and Math were used to address the first three research questions. Scaled scores are raw scores that have been adjusted to a standardized scale and can provide accurate comparisons for students who may have taken different test versions.

Results

To what extent do students' scores in third grade correlate with scores in later grades within each content area (English language arts and math)?

Results from a correlation analysis showed that a student's test scores (scaled scores) in third grade were consistently and significantly correlated with their scores in later grades in both English language arts and math. The figure below illustrates the strength of the relationships between third grade achievement in reading (blue) and math (gray) and achievement in subsequent grades. Although these correlations were strongest between grade 3 and grade 4 scores in both reading and math, the strength of the relations between grade 3 and all other grades remains relatively consistent throughout. The correlations between grade 3 math scores and math scores in later grades appear more variable, with a noticeable dip between third grade math and eighth grade math. Further consideration into why the correlations decrease in later grades for math is warranted. It may be the case that the content of the test is significantly different in some way or covers specific math concepts that are not as directly linked to earlier foundational concepts. Regardless, it is notable that despite this decrease, all these correlation coefficients are quite large.

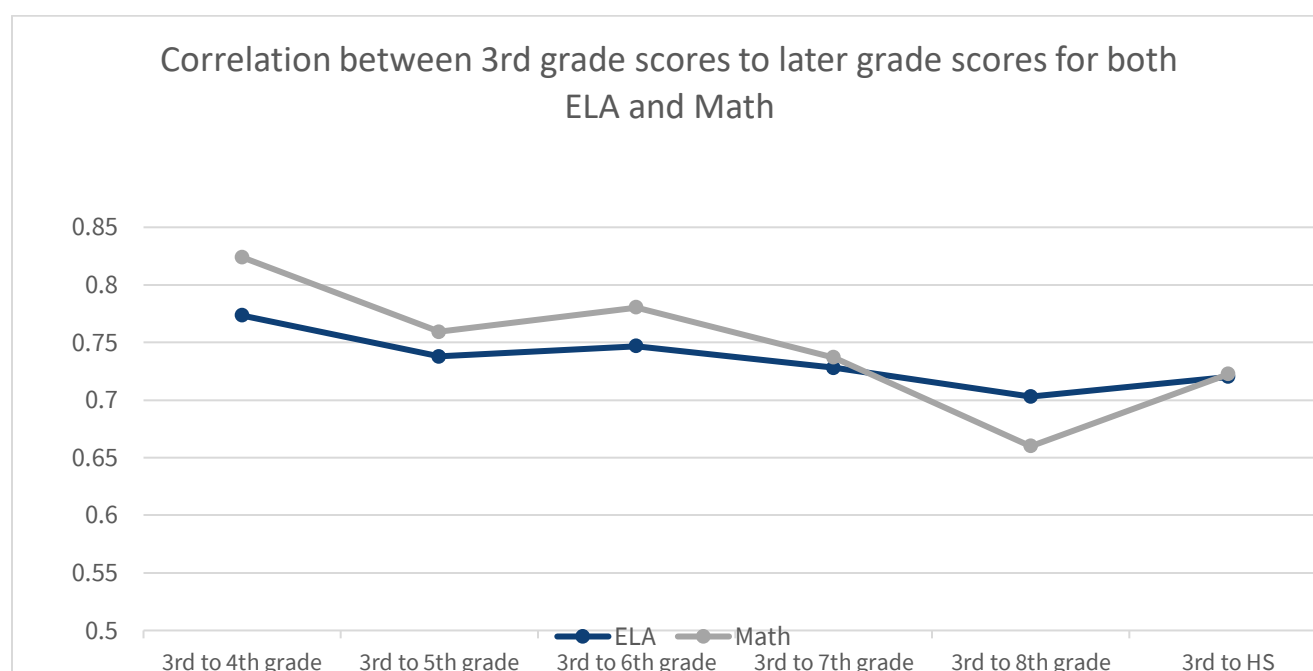


FIGURE 1. *Correlations between grade 3 scores and subsequent grades’ scores in reading (blue) and math (grey).*

To what extent do students’ grade 3 reading scores correlate to their later math scores, and vice versa?

A correlation analysis was conducted to determine the concurrent and longitudinal relationships between reading and math scores from third grade through high school. As seen in Table 1 below, the strongest correlations were for concurrent (same grade level) reading and math scores. The strength of the correlations between reading and math were consistently above 0.70 when measured at the same grade level (bolded in the table below).

	Gr3 Math	Gr4 Math	Gr5 Math	Gr6 Math	Gr7 Math	Gr8 Math	HS Math
Gr3 Read	0.74	0.70	0.65	0.69	0.65	0.57	0.64
Gr4 Read	0.69	0.74	0.70	0.70	0.68	0.57	0.65
Gr5 Read	0.67	0.71	0.73	0.74	0.70	0.62	0.66
Gr6 Read	0.69	0.69	0.71	0.78	0.75	0.67	0.69
Gr7 Read	0.67	0.70	0.68	0.74	0.76	0.69	0.71
Gr8 Read	0.65	0.679	0.69	0.71	0.73	0.71	0.73
HS Read	0.69	0.65	0.66	0.70	0.73	0.66	0.73

TABLE 1. *Correlations for reading and math scores from grade 3 through high school.*

Conversely, the relations between grade 3 reading scores and grade 3 through high school math scores declined slightly over time, as did relations between grade 3 math scores and English language arts scores at later grades. For example, in the table above, the correlation between grade 3 reading and grade 3 math is .74, but the correlation coefficients for grade 3 reading and later grade math scores declines.

To what extent do these correlations differ for various subgroups of students?

The results presented above pertained to the fully available sample of students without considering the possibility of different outcomes for different student subgroups. Reports outlining disaggregated data typically indicate lower overall scores on Ohio’s State Tests for English Language Arts and Math for Black and Hispanic students, as well as students with disabilities and multilingual learners. Therefore, a second step in this study was to further determine whether correlations between English language arts and math scores would differ as a function of student subgroup.

Results show that even after controlling for some demographic characteristics (students experiencing poverty, racial minority status, disability status, multilingual learner status, and gender), the correlations between English language arts and math tests remain high. For instance, the Pearson partial correlation coefficient is 0.65 among grade 3 English language arts and math, 0.69 among grade 6 English language arts and math, and 0.63 among high school English language arts and math (inclusive of English language arts 2, Algebra 1, Geometry, HS Math 1 and HS Math 2).

To what extent is the likelihood of achieving math proficiency associated with early reading skills?

Finally, it was of interest to examine associations between early literacy skills, prior to grade 3, and subsequent math scores. Student scores on an approved reading diagnostic, administered in the fall to all students in grades K-3, provided an estimation of student's trajectory to reading proficiency. The reading diagnostic categorized students as either being *on track* for grade-level reading proficiency or *not on track*. A student identified as *not on track* is required to have a Reading Improvement and Monitoring Plan (RIMP) that details a reading intervention plan for that student. There is no comparable state collection of math diagnostic scores for K-3.

Odds ratios were calculated to understand the association between early grade reading diagnostic results and later math proficiency in grade 3. Odds ratios provide an estimate of the probability that an outcome will occur — in this case, grade 3 math proficiency — based on the presence or absence of a specific condition — in this case, *on-track* reading status. Results from the odds analysis confirmed that literacy skills in the early grades are associated with math proficiency in grade 3. As seen in Figure 2, students who were on track on their fall reading diagnostic in kindergarten were 2.7 times more likely to be proficient in grade 3 math compared to students who were not on track. Those odds increased as students progressed through the grade levels. Students on track in reading in the fall of first grade have 3.1 times better odds of being proficient in grade 3 math, and students on track in reading in the fall of second grade have 4.1 times better odds of grade 3 math proficiency.

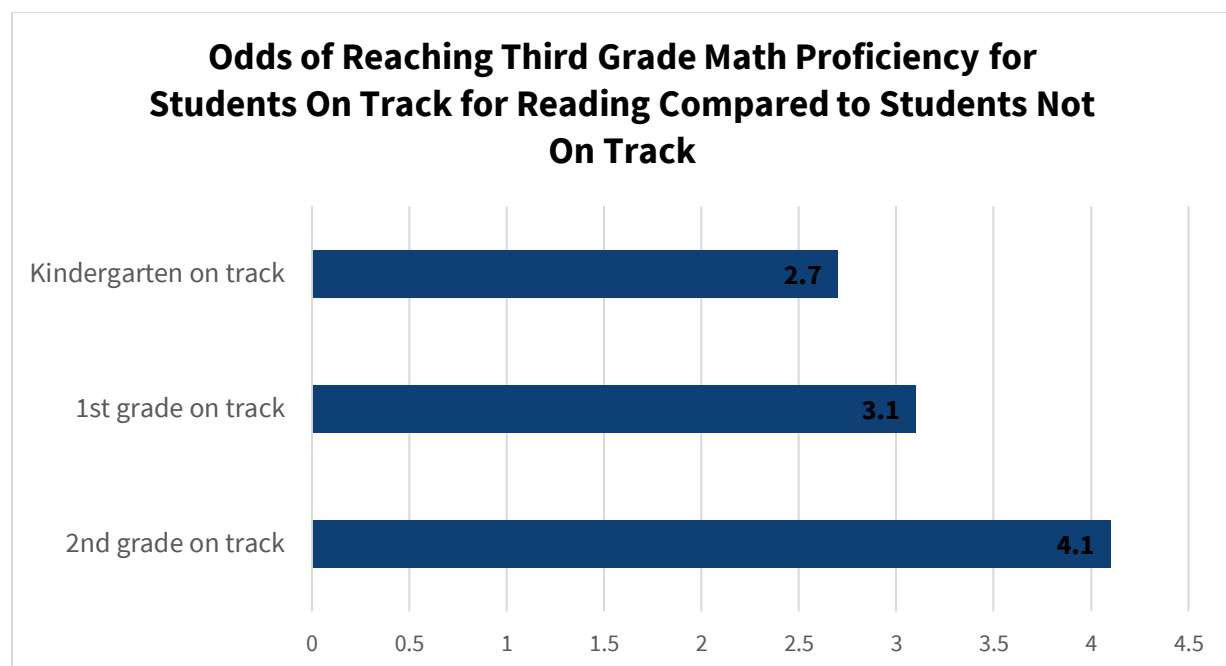


FIGURE 2. Illustration showing the odds of achieving third grade math proficiency if scoring on track in reading in grades kindergarten through second grade, compared to scoring not on track on those grades.

Conclusion

In Ohio, significant financial investments in time and resources have been put forth to ensure evidence-based reading instruction is accessible to all young students across the state and educators have the training and support to implement reading instruction effectively. As schools and districts begin making changes and shifts in instruction, it is important to remember these changes take time to implement, and perhaps even more time to see evidence of those changes in student outcomes. However, as the results from this study illustrate, investments in supporting literacy achievement are investments in math achievement as well. Future studies are needed to fully understand the potential causal nature of how reading and math are associated, but these findings, and existing literature, highlight the importance of continued and sustained support for Ohio's students and educators to maintain this momentum to improve academic achievement for students in Ohio.

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