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## A path analytic model linking foundational skills to Grade 3 state reading achievement

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### ABSTRACT

Considerable evidence supports that close to two thirds of all fourth-grade students read at less than adequate levels on reading achievement tests and that the problem has persisted for decades. This study of 1,064 third-grade students at risk for reading failure uses path analytic techniques to measure a hypothesized model linking developmental spelling, sight- and pseudo-word reading, and reading fluency to achievement on an end-of-year state reading test. While all hypothesized paths were found to be significant, paths not hypothesized were also significant. These paths included direct effects for spelling development on fluency and reading achievement, as well as the direct effect of sight-word reading on state reading achievement. In total, the model predicted 41.9% of the variance in state reading achievement and found that students proficient at foundational reading skills were 7 times more likely to be proficient on the state reading achievement assessment.

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Fluent reading; foundational skills; letter-sound relationships; path analytics; pseudo-word reading; sight-word reading; state reading accountability assessment

Despite a mean per-pupil expenditure in 2014 of \$12,774 (U.S. Census Bureau, 2014) resulting in over \$617 billion spent on K–12 education, 65% of fourth-grade students and 64% of eighth-grade students attain less than proficiency on the National Assessment of Educational Progress (2017). Moreover, results have shown languid improvement over the past two decades. Why, despite the billions of dollars spent by school districts over the decades, are up to two thirds of elementary students unable to reach reading proficiency on state and national assessments? We suggest one reason is underdeveloped foundational reading skills, which leave students struggling to focus their attention on understanding what they are trying to read. To further understand these relationships, we quantify the impact of spelling knowledge, pseudo- and sight-word reading, and reading fluency on a state accountability reading achievement assessment taken by third-grade students.

Through the use of what Hanushek and Raymond (2005) called “consequential accountability” measures (p. 298), state educational entities often attach escalating sanctions to specific benchmarks on state assessments. As such, attainment on these assessments has become the currency of education for which school districts are held accountable for earning. It is also clear that what is tested through state accountability assessment shapes the focus of the school curriculum (Glatthorn, Jailall, & Jailall, 2016; Sturman, 2003). End-of-year state reading assessments test the ability of students to understand and correctly answer questions after reading grade-level passages (Foorman, Petscher, & Schatschneider, 2015). However, such assessments rarely assess the critical underlying reading subskills that facilitate such understanding. Neglect of

reading subskills results in classroom instruction that gives insufficient attention to the development of the decoding and fluent reading skills, what are also called foundational skills, necessary to efficiently create textual meaning (Perfetti, 1985, 1988). We suggest one possibility for poor reading outcomes is that a large percentage of students are leaving third-grade with inadequately developed foundational skills (Daane, Campbell, Grigg, Goodman, & Oranje, 2005; Pinnell et al., 1995; Rasinski et al., 2017; Schatschneider et al., 2004). Additionally, few studies have analyzed the impact of foundational skills on end-of-year reading achievement assessments. We propose that district and school-based personnel do not fully understand the effect of foundational skills on the end-of-year performance of their students on assessments meant to assess attainment of state standards. The present study addresses this gap by using path analytics to test a hypothesized model specifying the relationships among letter-sound relationships, pseudo-word reading, sight-word reading, and fluent reading of connected texts to performance on an end-of-year state reading accountability assessment of third-grade students. This study contributes to the literature base by specifying the relationships between foundational reading skills and achievement on one state assessment of reading standards.

### Reading stages and spelling development

Ehri (1987; 1997) posited that poor readers are almost always poor spellers, but poor spellers are not always poor readers. To further understand this relationship, it helps to explore the stages of reading development (Chall, 1983) in relation to the

stages of spelling development (Gentry, 2000; Henderson & Templeton, 1986; Read, 1971; Templeton & Bear, 1992).

### Prereading stage

According to Chall, stage 0 is a prereading stage that generally occurs from birth to around 5 years old. During this stage oral and listening language skills begin to shape future reading development. In addition to oral speech, listening, and language development, other key aspects of reading development are also occurring. Stage 0 readers are beginning to develop alphabetic knowledge and phonemic awareness, along with important understandings related to concepts about print. Readers in this stage rely heavily on their environment and context to help them read highly predictable and repetitive books. Readers progressing through stage 0 are described as logographic or cue readers who are successful at identifying signs and logos in their environment and who try to apply their knowledge of visual cues to recognize words (Ehri, 1987; Heilman, Blair, & Rupley, 2002).

Concurrently learners are in the preliterate stage of spelling development (Henderson & Templeton, 1986). At this stage writing and spelling are represented by scribbles that may include some symbols and occasionally letter form production that demonstrates no knowledge of letter-sound correspondence. Spelling attempts appear to be a random stringing together of letters of the alphabet and other symbols such as numbers. Spellers in this stage are beginning to represent the principle of left-to-right directionality, but may not yet demonstrate other concepts such as spacing or word representation in their writing. As learners move through the preliterate stage of spelling, they begin to know more letters of the alphabet but use upper- and lowercase letters indiscriminately.

### Decoding stage

Once learners enter the cipher phase of reading they have now progressed into Chall's stage 1 of reading development in which they begin using phonetic analysis as a primary strategy to decode unknown words (Rupley, Willson, & Logan, 1995). The reader "glues to print" (Chall, 1983, p. 18) and the eyes often fixate on each letter of a word. Even words that may have been previously recognized by sight are now phonetically analyzed. The reader can identify the beginning and ending letter sounds, as well as most short vowel sounds in monosyllabic words. It is at this point that the child is progressing in spelling development and is now entering the letter name stage. In this stage children begin to conceptualize that letters have sounds that are used to represent sounds in words. Learners primarily use a letter-name rather than a letter-sound strategy in their spelling, such as using *JL* to represent jail. At this point, the learner is moving into Ehri's (1987) phonetic cue phase of reading and is making associations between spelling and pronunciations. As learners progress further into stage 1 of reading development they can begin to decode some single-syllable words and can typically recognize initial onset and often ending sounds, but may struggle with medial vowel sounds. Learners may overgeneralize vowel sounds and sometimes refuse to read if they are unable to break the phonetic code. The learner in

this stage of reading development continues to struggle with multisyllabic words and more complex vowel patterns.

### Confirmation stage

As the reader transitions into Chall's stage 2, his or her word recognition accuracy increases and the reader is now able to decode more multisyllabic words. According to Gentry (2000), this stage of spelling development is the transitional stage or what Henderson and Templeton (1986) call the within-word stage. As the learner continues to deepen their inventory of sight words, spellings become more accurate due to the ability to examine words systematically around specific, salient features. In the early within-word stage readers can provide the correct representation of short vowels, including words containing both a sounded and silent vowel (e.g., "take"). The transitional speller adheres to basic conventions of English orthography, and vowels begin to appear in each syllable. The learners in this stage of development begin to show evidence of a developing visual strategy as they transition from phonological to morphological and visual spelling (Willson & Rupley, 1997). The learner also realizes that there are multiple vowels in a word, but may still reverse the order of the vowel representation. Transitional spellers may use alternate spellings for the same sound, but can usually use correct spellings in their writing for a greater abundance of words. Learners at this stage of their reading have not fully developed capabilities related to stress, morpheme boundaries, or phonological influences.

Continuing growth in stage 2 enables readers to rely more heavily on contextual analysis to decode unknown words and in essence they have become multistrategic when decoding unfamiliar words. Progress by the reader in reading fluency has a reciprocal impact on their spelling development, which continues to advance as well. According to Henderson and Templeton (1986), the learner progresses into the syllable juncture stage where they demonstrate more exceptional command of complex letter features including consonant doubling, *e*-drops for *-ed* and *-ing*, and *r*-controlled vowels. The final spelling stage, derivational constancy, consists of silent and sounded consonants and Latin-derived affixes. Understanding and mastering the various combinations of developmental spelling patterns has been shown to lead to a faster accumulation of sight words and the attainment of reading fluency (Aghababian & Nazir, 2000; Zutell, 1992). Gentry (2000) referred to this last stage of spelling development as the correct or conventional spelling stage. During this stage of development, the speller's knowledge of the English orthographic system and its basic rules are firmly established.

### Word reading

Effective word reading involves the accurate and rapid mapping of letter-sound correspondences and is vital to fluent reading (Ehri, 2005; Hudson, Torgesen, Lane, & Turner, 2012; Ouellette, 2006; Torgesen, Rashotte, & Alexander, 2001). Theorists suggest that a word has become automatized when the reader no longer needs to apply decoding processes to unlock its pronunciation (LaBerge & Samuels, 1974; Logan, 1988). The word is then recognized through an independent lexical route

in which it is activated orthographically as a complete unit or sight word (Coltheart, 2005; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Ehri, 2014). Others have suggested that rather than being independent, the two routes work interactively (Carr & Pollatsek, 1985). When word retrieval speed is efficient both orthographic and semantic information is activated interactively, which assists in maintaining the working memory space necessary for comprehension processing (Coltheart, 2005; Harm & Seidenberg, 1999). An example of the importance of well-developed foundational skills is reflected in a recent study of kindergarten and third- and 10th-grade readers (Stanley, Petscher, & Catts, 2017). The authors found that non-sense-word and letter-naming fluency in kindergarten exert direct effects on 10th-grade reading comprehension, supporting the importance of foundational skill development to later reading achievement.

### Reading fluency

Reading fluency is suggested by an interaction of (a) word identification accuracy, (b) automaticity (also called rate or pacing), and (c) the application of appropriate prosodic features to the reading (Samuels, 2007; Shanahan, 2006). Correct identification of words includes neither skipping nor inserting words and the avoidance of repeating words or phrases. Whether reading aloud or silently, automaticity reflects the speed at which the reader progresses through the text. Appropriate oral automaticity has long been thought to loosely reflect conversational speech (Bear, 1992; Betts, 1946). It is the proficient interaction between word identification accuracy and automaticity, or “automaticity” (Paige, Magpuri-Lavell, Rasinski, & Rupley, 2015, p. 105), that is reflected in the metric words correct per minute (WCPM). It has been suggested that a minimum WCPM criterion is necessary to support basic comprehension (Paris & Hamilton, 2009). Although the present study does not focus on prosody, it is this indicator that conveys expression, pitch, stress, and phrasing to make both oral and silent reading reflect conversation. Fluent reading is essential to comprehension as multiple authors have shown it contributes from 25% to 50% of the variance in comprehension through the middle grades and beyond (Dowhower, 1991; Fuchs, Fuchs, Hosp, & Jenkins, 2001; Paige, 2011; Paige, Rasinski, Magpuri-Lavell, & Smith, 2014; Rasinski, Rikli, & Johnston, 2009; Schreiber, 1991).

### Vocabulary and comprehension

This study is focused on the role of foundational skills in reading, the sole purpose of which is to facilitate the construction and critical reflection of the author’s message (Paris & Hamilton, 2009). General agreement has been established among researchers that comprehension occurs through both bottom-up (letter and word identification) and top-down (macro or global propositions) processes reflected in an interactive view of the meaning-creation process (Just & Carpenter, 1987; Kintsch, 1988; Verhoeven & Perfetti, 2008). An interactive perspective of comprehension elucidates the understanding that while decoding words and fluently reading text is a necessary reading ability it does not guarantee one will be able to understand the words and comprehend the text (Cain & Oakhill,

2003). Nevertheless, there is an essential relationship between word reading and comprehension where those who are poor word readers are much more likely to be poor comprehenders (Perfetti & Hart, 2002). Perfetti (1992) hypothesizes that orthographic, phonological, and semantic information systems are required to create the kind of high-quality lexical representations that enable comprehension. For example, poor orthographic knowledge can result in a less than adequate phonological representation that is insufficient to unlock semantic information that results in the word remaining unknown to the reader (Carver, 1994). So, while a word may be part of the student’s listening vocabulary, if not unlocked from the page it is unable to aid in the reader’s textual understanding. Mapping word recognition to meaning is critical, as Carver (1994) suggested that for adequate reading comprehension to occur the reader must understand nearly 100% of the words. It is through automatic word recognition that readers can devote their limited cognitive resources to meaning-making at the word-to-text sentence integration level and with their prior knowledge that then results in a situation model (Perfetti, 1985, 1998; Samuels & Flor, 1997; Spear-Swerling & Sternberg, 1994). It is the situation model where the reader integrates their prior and global knowledge with the author’s message.

### Theoretical framework

Verbal efficiency theory (Perfetti, 1985, 1988) hypothesizes that differences in what a reader understands about a text are determined by the efficiency of the underlying reading subskills or “local processes” (Perfetti, 1985, p. 100). Verbal efficiency theory assumes that comprehension requires cognitive resources, explicitly working memory (WM), which is available to readers in limited amounts. Use of WM can be directed to a variety of processes including word identification, inferencing, integrative processes, and syntactic repairs. Of those, word identification is one that can be trained to automatic levels, making the process low-resource consuming and allowing for the direction of WM capacity to comprehension processing (LaBerge & Samuels, 1974; Logan, 1988). An individual’s understanding of the orthographic relationships that form the basis of decoding results in accurate word identification that becomes fast and efficient (automatic) and leads to fluent reading (Rupley, 2009). Alternately, poor decoding skill leads to low-quality word identification (Ehri, 2005; Ehri & Saltmarsh, 1995), reduced reading fluency (Daane et al., 2005; Paige, Rasinski, & Magpuri-Lavell (2012), and too often, poor comprehension (Kucer, 2009).

### Research questions

The objective of this study is to test a theoretical model in which developmental spelling knowledge, word reading, and reading fluency affect reading achievement on a state-administered reading assessment. Our research questions were the following:

- Research Question 1. To what extent is spelling knowledge, sight- and pseudo-word reading, and reading fluency developed in end-of-year third-grade students?
- Research Question 2. What are the strengths of the paths in a hypothesized model containing spelling knowledge,



sight-word- and pseudo-word reading, reading fluency, and achievement on a state-administered reading test?

Research Question 3. What is the likelihood that a student proficient in spelling knowledge and reading fluency will attain proficiency on a state-administered reading test?

We hypothesized that pseudo- and sight-word reading is dependent on spelling knowledge. We also hypothesized that fluent reading is dependent on the reader's sight-word reading ability. Finally, we hypothesized that achievement on a state reading accountability test is dependent on fluent reading.

## Method

### Participants

This study was conducted in a large, midwestern, U.S. school district. The district was participating with several of the study authors in an ongoing district-university partnership to improve teacher capacity for reading instruction. The district consisted of 90 elementary schools, of which 31 (34.4%) were participating at the time of the present study. These schools were purposely selected by the district as they were the lowest academically performing schools in the district. First- through third-grade teachers from the 31 schools were invited by their principals to volunteer to participate in 90–180 hr of training, for which they received 6–12 hr of graduate course credit, respectively. Training was conducted in traditional face-to-face classes that were delivered on site in the participating district schools. The training curriculum consisted of knowledge of reading fundamentals in the five domains of phonemic and phonological awareness, reading fluency, vocabulary, and comprehension. Curriculum also included instruction on the administration and use of reading assessments, as well as instructional practices in the teaching of the five domains of reading. Training also included practices to encourage family literacy activities. Because teachers volunteered to participate in the project, the number of teachers per school varied from one to three. The student sample and unit of analysis for the present study are 1,064 third-grade students who were instructed by 52 teachers from the 31 participating elementary schools. Of the students attending the 31 schools, 85.6% received free or reduced-price lunch. A total of 46.9% were African American, 33.2% were Caucasian, 12.4% were Hispanic, and 7.5% were one of several other ethnicities. An analysis by gender revealed that 50.2% of students were boys while 49.8% were girls. The student sample comes from 34 U.S. census tracts in which the mean percent of residents living in poverty was 43.3 ( $SD = 13.3$ ) and varied between a high of 86.7% and a low of 22.5%, with a median percentage equal to 44.2%. Students with mild-to-moderate disabilities numbered 146 (13.7%), while English language learners totaled 129 (12.0%). The average age of students at the time of assessment was 8 years, 8 months old.

### Assessment instruments

The measures used in this study were selected based on the value of the information they provided teachers regarding the critical reading subskills of their students. A second consideration was

the ease of administration of each assessment as all teachers participating in the partnership were trained in their administration and interpretation. The assessments were administered three times per year by the participating teachers to each student in the class with those administered in May reported in this study.

### Developmental spelling

The Developmental Screening Inventory (DSI; Ganske, 2014) is a group administered spelling assessment composed of 20 words that increase in spelling complexity. These 20 words are grouped into four sections of five words each that represent the four stages of spelling development (letter naming [LN], within-word [WW], syllable juncture [SJ], and derivational constancy [DC]) as described by Henderson and Templeton (1986). The DSI provides a measure of the child's orthographic knowledge (Ehri, 1993; Ganske, 1994, 2014). Mastery of the LN stage means students understand initial and final consonants, blends, and digraphs, short vowels, and affricates (the speech sounds heard at the beginning of job and chop). The WW stage consists of letter-sound combinations made by long vowels (e.g., *ate*) and *r*-controlled vowels (letter features in which *r* follows a vowel or team of vowels such as in *hurt*, *fear*, *girl*, and *bird*). Also in the WW stage are other common combinations of letters representing long vowel sounds (i.e., *ai*, *ay*, *ee*, *ea*, *oa*, and *ui*), complex consonant sounds (i.e., *ck*, *kn*, *scr*, *thr*, *tch*), vowel units (i.e., *dge* and *qu*), and abstract vowel sounds such as those read in *pout*, *cow*, *toy*, *boil*, and *few*. The SJ stage includes features such as doubling (*jog* and *jogged*) and the *e*-drop with *-ed* and *-ing*, long vowel patterns and *r*-controlled vowels within a stressed syllable, and vowel patterns within an unstressed syllable. The DC stage includes silent and sounded consonants, Latin-derived suffixes, and assimilated prefixes. The DSI is untimed and group-administered where the teacher pronounces the target word aloud, reads it in a sentence, and then repeats the word. Students are given time to spell the target word on paper. Scoring of the DSI is done by awarding 1 point for each correctly spelled word for a total possible score ranging from 0 to 20. The assessed range in this study is 0 to 20, with 19 students attaining a score of 20. Two forms of the DSI are available, with Form A used in this study. Pearson *r* correlations for the five words comprising each of the four spelling stages as reported by the author range from .97 to .99 while test-retest correlations range from .97 to .98.

### Word reading

Word reading is assessed using the Test of Word Reading Efficiency-2 (TOWRE; Torgesen, Wagner, & Rashotte, 2014). The TOWRE consists of two subtests that determine a student's ability to efficiently (a) read sight-words (SWE) and (b) phonologically regular pseudo-words (PDE). The TOWRE is available in four forms, with Form B used in this study. The test is administered individually to each student. For each subtest, the student has 45 s to read aloud increasingly complicated words that are aligned in columns on the test page. The test administrator marks words read incorrectly with the raw score equal to the number of words read correctly for each subtest. The maximum possible score is 66 for pseudo-word reading and 108 for

sight-word reading. In this study, the range of scores on the pseudo-word test (PDE) was 0–64 whereas the range on the sight-word test (SWE) was 0–94. Test-retest reliability coefficients for the assessed age group equals .92 for the sight-word test and .87 for the pseudo-word test.

### Reading fluency

To assess fluent reading, students individually read aloud a curriculum-based narrative passage for 3 min while being scored for reading miscues (omissions, insertions, mispronounced words, reversals and skipping a line) by the test administrator. If after 3 s students were unable to read a word it was counted as an error, and the student was directed to continue reading. Total time spent reading was recorded for those who finished in less than 3 min. The passage was measured for Lexile complexity using the Lexile Analyzer (MetaMetrics, 2016) resulting in a 332-word, 700–800 L passage that is within the text complexity grade bands identified by the Common Core State Standards Initiative (2010) as appropriate for third-grade readers (420–850 L). To further assess text readability, the text was analyzed using Coh-Metrix (Graesser, McNamara, & Kulikowich, 2011), which determined it to be high in narrativity (75%), syntactic simplicity (77%), and word concreteness (85%), while low in referential and deep cohesion (18% and 46%, respectively). Curriculum-based measures have been shown to be valid measures of reading competency (Fuchs, Fuchs, Hosp, & Jenkins, 2001) while also possessing adequate reliability (Deno, 1985; Deno, Mirkin, & Chiang, 1982; McGlinchey & Hixson, 2004). The range of reading fluency scores for this group of students was 0 to 200. Reliability of the present data was determined using a split-half reliability test conducted on cases resulting in Pearson's  $r = .991$ . While we subscribe to a definition of fluency as being composed of the three indicators of rate, word identification accuracy, and prosody, this study does not assess prosody due to the difficulty associated with its measurement across a large number of students (Trainin, Hayden, Wilson, & Erickson, 2016). For interpretational ease, we will refer to the metric of WCPM as fluency.

### State reading achievement

The Kentucky Performance Rating for Education Progress (K-PREP) is a blended model of a criterion and norm-referenced test containing multiple-choice and constructed-response items designed to test attainment of state reading standards and is not meant as a test of reading comprehension. Instead, the assessment is driven by the state school system as a metric to assess districts in an accountability environment in which the focus is on increasing test scores. K-PREP results are reported as scale scores which are calculated from raw scores to provide a consistent metric that is comparable across grades and content areas. K-PREP scale scores range from 100 to 300, with the range in this study being 154 to 287. Achievement is classified into four categories with third-grade scores between 100 and 197 indicating novice performance, 198 and 209 representing the apprentice level, 210 and 225 defining proficiency, and 226 and 300 equaling distinguished achievement. We refer to all scores at the proficient and distinguished level collectively as proficient. In an analysis of the assessment, the

study authors reported the Lexile range of the text as between 600 L and 850 L (MetaMetrics, 2012). Reliability measures for this assessment indicated by the test maker are a Cronbach's  $\alpha$  of .89. The K-PREP has been determined to meet validity arguments, suggesting that it is a valid measure of student achievement of the state reading standards.

### Assessment administration

As part of a broader instructional improvement initiative conducted by the district, teachers were trained to administer the DSI, TOWRE-2, and the narrative reading passage during the first of two graduate-level reading classes that began in the fall of 2015. Teachers were instructed on the administration of each instrument during the initial four classes of the fall semester. For the fifth-class teachers returned with one set of completed student assessments (DSI, TOWRE, and fluency passage) for review and feedback from the instructor. For the next class teachers returned with two sets of completed assessments. Assessments were then blindly scored by both the instructor and student and compared for reliability. Students whose grading did not wholly agree with that of the instructor were immediately remediated to correct the scoring error. Those teachers were then required to bring a second set of assessments from two different students to class the following week to repeat the scoring procedure with the instructor. After all teachers demonstrated scoring that was in 100% agreement with the instructor, blind scores for both raters were returned to the researchers for another round of reliability checking. After training and reliability checking, teachers then administered all assessments to their remaining students. During December of the school year, teachers again administered the same assessments to all students in their class while a third round of the same assessments was administered in May of the school year. Because of the temporal distance between the three assessment periods the administration training protocol described above was repeated in April as preparation for the May assessment period. The goal was again 100% agreement between the instructors and students, which was confirmed by the researchers. Data from the May assessment period are used in the present study.

The KPREP was administered at the end of April by the school district. Because the KPREP is a state accountability assessment, the administration procedures are explicitly outlined by the state. Before testing begins, teachers are trained in their school building on test administration and security. Of significant concern is that the test is in no way compromised meaning teachers are instructed to avoid providing any assistance to students and to not record any test questions. Test administration directions direct teachers to explain to students how to fill out the test booklet and to verify the classroom environment will not prohibit students from completing the test. Teachers are instructed to circulate among students during testing to monitor the classroom testing environment. Materials are gathered from all teachers at the expiration of testing by administrators and returned to a secure location.

### Results

Research Question 1 sought to determine the developmental level of students on the measured variables. Table 1 shows the

**Table 1.** Mean and bivariate correlation data of the measured variables.

	Spelling	Sight-word reading	Pseudo-word reading	Reading fluency	Reading achievement
Spelling	1.0				
Sight-word reading	.624**	1.0			
Pseudo-word reading	.649**	.793**	1.0		
Reading fluency	.656**	.812**	.754**	1.0	
Reading achievement	.515**	.577**	.542**	.627**	1.0
<i>M</i> ( <i>SD</i> )	8.08 (4.37)	57.21 (16.56)	27.47 (12.24)	76.31 (36.08)	199.23 (23.10)
Range	0–20	0–94	0–64	0–200	154–287

\*\* $p < .01$ .

means, ranges, standard deviations, and bivariate correlations for the measured variables while Table 2 provides attainment by percentiles. Spelling knowledge shows a mean score of 8.08 ( $SD = 4.37$ ) suggesting attainment in the WW stage. The sight- and pseudo-word means of 57.21 ( $SD = 16.56$ ) and 27.47 ( $SD = 12.24$ ) respectively, show attainment commensurate with the 37th percentile for both measures. Reading fluency measured in WCPM resulted in a mean of 76.31 ( $SD = 36.08$ ) reflecting attainment at approximately the 25th percentile on the Hasbrouck and Tindal (2006) reading fluency norms. The mean of 199.23 ( $SD = 19.10$ ) on the state reading achievement assessment shows attainment at the very low apprentice level ( $\approx 26$ th percentile) per the state interpretation table. An analysis of the bivariate correlations shows large correlations among all variables with the largest between sight-word reading and fluency ( $r = .81$ ), pseudo- and sight-word reading ( $r = .79$ ), and pseudo-word and reading fluency ( $r = .75$ ).

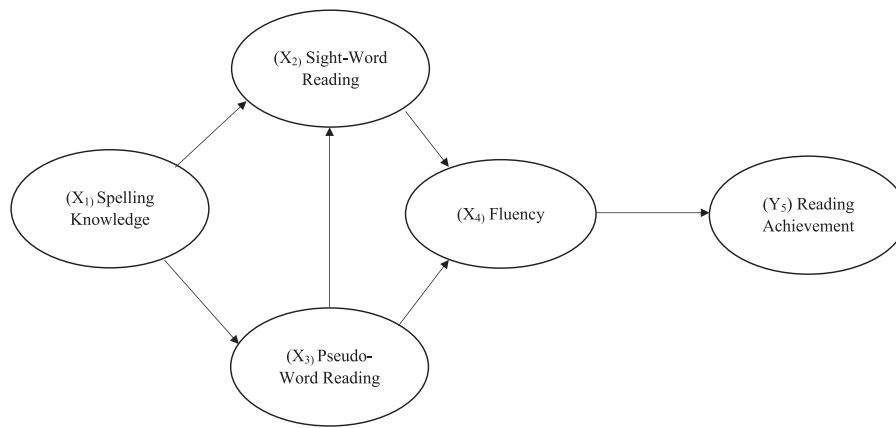
Research Question 2 sought to analyze the strengths of the paths in the hypothesized model (Figure 1). The model shows sight-word (x2) and pseudo-word (x3) reading regressed onto spelling knowledge (x1), sight-word reading (x2) regressed onto pseudo-word reading (x3), fluency (x4) regressed onto sight-word reading (x2) and pseudo-word reading (x3), and reading achievement (x5) regressed onto fluency (x4). Before modeling the data, we checked assumptions that must be true to draw conclusions from the sample (Berry, 1993). Multicollinearity was absent between variables, as evidenced by variance inflation factors well below 10 and tolerance statistics greater than 0.2 (Myers, 1990). To check for homogeneity of variances we applied Levene's test to residuals, which resulted in nonsignificant tests for spelling knowledge,  $F(1, 1063) = 1.61, p = .21$ ; pseudo-word reading,  $F(1, 1063) = 0.625, p = .429$ ; sight-word reading,  $F(1, 1063) = 2.86, p = .091$ ; fluency,  $F(1, 1063) = 1.18, p = .277$ ; and reading achievement,  $F(1, 1063) = 0.532, p = .466$ . Residual errors in the model were found to be random and independently distributed with a mean of 0 and a standard deviation of 1. Finally, we checked for lack of serial correlations between errors and found no violation (Durbin-Watson value = 1.45).

When a linkage has been omitted from a theoretical model, the expected magnitude of the path coefficient is zero. Asher (1983) recommended the use of decomposition as a way to assess model adequacy when some linkages have been omitted from the hypothesized model to determine if the path coefficients are, in fact, zero. Figure 2 shows the completely measured path model in which omitted linkages result in coefficients significantly greater than zero. Standardized beta coefficients along with direct and indirect effects are shown in Table 3. Spelling knowledge now reveals a direct path to sight-word reading ( $r = .196, p < .001$ ), pseudo-word reading ( $r = .649, p < .001$ ), fluency ( $r = .192, p < .001$ ), and reading achievement ( $r = .157, p < .001$ ), while pseudo-word reading is shown to exert a direct effect on sight-word reading ( $r = .660, p < .001$ ). Both sight-word and pseudo-word reading exert direct effects on fluency ( $r = .518, p < .001$  and  $r = .215, p < .001$ , respectively) while sight-word reading also has a direct effect on reading achievement ( $r = .160, p < .001$ ). To conclude the model, fluency has a direct effect on reading achievement ( $r = .395, p < .001$ ). Total variance explained by the measured model is  $R^2 = .419$ .

The third research question asked the likelihood that a student proficient in foundational skills will attain proficiency on the state-administered reading achievement test. To answer this question, we created a continuous variable called foundational skills that combines spelling-knowledge and reading fluency. We established a cutpoint of 9 on the developmental spelling-knowledge test to represent end-of-Grade 3 proficiency. We chose a score of 9 as it indicates competency with letter-sound correspondences well into the within-word stage that includes *r*-controlled vowels, complex consonants, and long and abstract vowels. We set reading fluency equal to a WCPM score of 95, as this indicates the student can proficiently read an end of third-grade narrative text (700 ;L to 800 ;L) at a level commensurate with the 40th percentile on the Hasbrouck and Tindal (2006) fluency norms. Levels below the 40th percentile have been suggested to reflect a struggling reader (Hock et al., 2009).

**Table 2.** Attainment levels by percentile for the measured variables.

Percentile	Spelling knowledge	Pseudo-word reading	Sight-word reading	Reading fluency	Reading achievement
10th	3.00	11.00	33.00	25.60	177.00
25th	5.00	18.00	49.00	50.00	186.00
50th	7.00	27.00	60.00	77.67	198.00
75th	11.00	36.00	68.00	103.00	210.00
90th	14.00	44.00	74.00	117.63	223.00
<i>M</i> ( <i>SD</i> )	8.08 (4.37)	27.47 (12.24)	57.21 (16.56)	76.31 (36.08)	199.23 (23.10)



**Figure 1.** Hypothesized model of the relationships among spelling knowledge, sight-word reading, pseudo-word reading, fluency, and reading achievement.

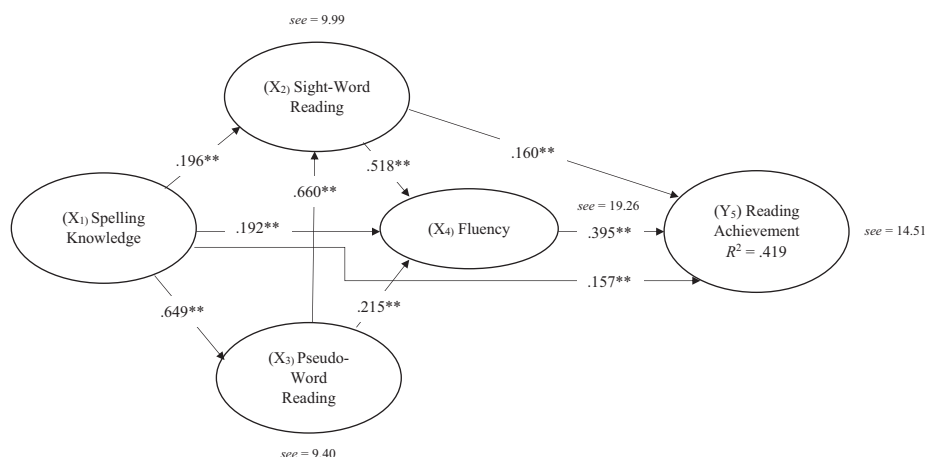
To assess the effect of foundational skills on state reading achievement, we wished to sum the two measures (spelling knowledge and fluency) to construct a composite indicator. Because the two metrics are interval scales with different ranges (spelling knowledge ranges from 0 to 20 and fluency ranges from 0 to 200) and we desire that each measure be equally weighted, it is necessary to transform the data before summing. When measures are interval scales, an affine transformation is appropriate to preserve rank-order as well as distance between the scores. According to Crocker and Algina (1986), if  $X$  is an interval scaled measure and  $Y$  represents the transformed measure, the only transformation that will retain all the information contained in the original measures is of the form  $Y = aX + b$  where  $a$  and  $b$  are constants. Before combining the measures into a composite value, the distribution of spelling knowledge scores was transformed with the affine transformation  $Y = 10(X) + b$  where  $Y$  = the transformed measure, and  $X$  = the original measure, and  $b = 0$ .

After summing the transformed spelling knowledge and reading fluency variables, the new foundational skills variable was found to have a range of 0 to 400 with a mean equal to 156.04 ( $SD = 72.65$ ). Scores  $\geq 185.0$  became the transformed cut score representing proficient foundational skills (90 for spelling knowledge plus 95 for reading fluency). We then created categorical variables for foundational skills and the state

reading assessment where proficient scores were dummy coded as 1 and less than proficient as 0. The reason for this was to assess the relationship between the two variables through the lens of educational practitioners who view educational outcomes as a binomial variable. In such a view, students either achieve proficiency or they do not. A frequency count revealed 31.00% of all students met the criteria for proficient foundational skills whereas 27.7% attained reading achievement proficient. To determine the predictive strength of a student being both foundational skills and state reading assessment proficient, we conducted a logistic binary regression analysis by regressing foundational skills onto the state reading proficiency measure. The resulting chi-square test (Table 4) shows that foundational skills are a statistically significant predictor of state reading proficiency,  $\chi^2(1) = 193.62, p < .001$ , with the Nagelkerke  $R^2$  analog = .220, and a statically significant Wald test, Wald, 180.70(1),  $p < .001$ . The odds calculation reveals that a student proficient in foundational skills is 6.94 times more likely to be proficient on the state reading assessment than students who are less than proficient at foundational skills.

## Discussion

In this study, we use a path analytic model to assess the fit of an a priori model of developmental spelling knowledge, pseudo-



**Figure 2.** Path model of the relationships among spelling knowledge, sight-word reading, pseudo-word reading, fluency, and reading achievement. SEE = standard estimate of error.



**Table 3.** Summary of direct and indirect effects by variable for hierarchical regression analysis.

Outcome	R <sup>2</sup>	Determinant	Direct effects (se)	Indirect effects	Total effects
SWE	.641	Spelling knowledge	0.196*** (0.091)	0.428***	0.624***
		Pseudo-word reading	0.660*** (0.033)	0	0.660***
PDE	.421	Spelling knowledge	0.649*** (0.065)	0	0.649***
		Spelling knowledge	0.192*** (0.185)	0	0.192***
Fluency	.704	Sight-word reading	0.518*** (0.060)	0	0.518***
		Pseudo-word reading	0.215*** (0.084)	0	0.215***
		Spelling knowledge	0.157*** (0.138)	0.204***	0.361***
		Sight-word reading	0.160*** (0.047)	0.205***	0.365***
		Pseudo-word reading	0.000	0.085***	0.085***
RdngAch	.419	Fluency	0.395*** (0.022)	0	0.395***

Note. All coefficients are standardized coefficients. SWE = sight-word efficiency; PDE = pseudo-word efficiency; RdngAch = reading achievement.

\*\*\* $p < .001$ .

word reading, sight-word reading, and reading fluency to predict third-grade reading achievement on a state-level accountability test in a sample of 1,064 students. Our results show first that the model explains 41.9% of the variance in reading achievement. Second, we found that spelling knowledge was critical as it directly contributes to sight- and pseudo-word reading, fluency, and reading achievement. Third, we found that students proficient in spelling knowledge and fluent reading (foundational skills) were more likely to score proficient on the state reading assessment with the odds ratio equal to 6.94. In our sample of end-of-Grade 3 students, we found mean spelling knowledge to be in the WW stage ( $M = 8.08$ ), while word reading achievement was at the 37th percentile for both pseudo- and sight-word reading on a norm-referenced test. Reading fluency attainment was at the 25th percentile while mean performance on the state-administered reading test was commensurate with the 26th percentile.

Of particular interest are the statistically significant, nonhypothesized paths from spelling knowledge to fluency ( $r = .192$ ), spelling knowledge to reading achievement ( $r = .157$ ), and sight-word reading to reading achievement ( $r = .160$ ). While spelling knowledge was hypothesized to be a significant predictor of both pseudo- and sight-word reading, we did not expect to find the total effects ( $r = .361$ ) to be nearly as strong as those for sight-word reading ( $r = .365$ ) and fluency ( $r = .395$ ). Neither did we expect to find spelling knowledge to be a direct predictor of state reading achievement. A contribution of this study is that, first, it specifies the role of letter-sound correspondence as measured by spelling development in relation to pseudo- and sight-word reading, and reading fluency development and two, it highlights the importance of letter-sound knowledge to reading achievement on a state accountability assessment.

Sight-word reading is vital to efficient reading, and our model finds both spelling knowledge and pseudo-word reading to be significant predictors with total effects equal to .624 and

.660, respectively. Spelling knowledge measures what the student understands about letter-sound relationships through the writing of words while pseudo-word reading reflects the ability to apply this same knowledge to the reading of words. An example of this is found in the word *few* where the word could be rewritten by replacing the /f/ with the digraph *ph* resulting in *phew*. Students with knowledge of the *ph* digraph in words such as *photo* and *alphabet* would quickly be able to transfer that understanding to correctly pronounce the pseudo-word *phew*. The correlation coefficient of  $r = .649$  (Table 1) suggests that while spelling knowledge and pseudo-word reading are related, they are not wholly reciprocal processes. Further evidence of their distinct contributions to sight-word reading is found in the fact that each explains unique variance.

When considering reading fluency, spelling knowledge, sight-word reading, and pseudo-word reading were found to each explain unique variance. Sight-word reading was by far the strongest predictor ( $b = .518$ ), while spelling knowledge ( $B = .192$ ) and pseudo-word reading ( $b = .215$ ) were similar in magnitude. Of interest is that pseudo-word reading, while being a direct predictor of sight-word reading, explained additional unique variance in oral reading fluency. These three predictors suggest a slightly different scenario when state reading achievement is examined. The magnitude of the total effects for spelling knowledge, sight-word reading, and reading fluency were found to be of similar size with beta coefficients of .361, .365, and .395, respectively, while pseudo-word reading was also significant, but at a much smaller magnitude ( $b = .085$ ).

Although our a priori model suggested that fluency would be the sole predictor of state reading achievement, the final model reveals that spelling knowledge, sight-word reading, and fluency explain very similar amounts of variance in state reading achievement, while pseudo-word reading explains a statistically significant, but much smaller amount. These results suggest several notions regarding the skills necessary to do well on this particular state assessment. First, efficient spelling knowledge

**Table 4.** Results of binary logistic regression analysis for state reading proficiency regressed onto foundational skills.

	B (SE)	Wald (df = 1)	95% CI for odds ratio		
			Lower	Odds ratio	Upper
Foundational skills	1.94 (0.144)	180.70***	5.23	6.94	9.21
Constant	-1.72 (0.098)	360.91***			

\*\*\* $p < .001$ .

skills are critical as evidenced by the idea that not only were the expected indirect effects present ( $b = .204$ ), but additional and significant direct effects were also found ( $b = .157$ ), which suggests that students with strong letter-sound correspondence knowledge experienced an advantage over students with lesser skills. A second finding was the fact that like spelling knowledge, we also found direct effects on state reading achievement for sight-word reading in addition to the hypothesized indirect effects. While our observations pertain to the results of this particular study, there is reason to think that both of these skills are likely essential to success on other state tests. For example, a recent analysis of the PARCC (Partnership for Assessment of Readiness for College and Careers) and Smarter Balanced assessments found that both required students to engage in extensive close reading and text analysis, focus on main ideas and supporting details, and make frequent use of direct textual evidence and higher order thinking skills (Doorey & Polikoff, 2016). Our study did not attempt to measure these various skills, the result of which would likely yield additional explained variance in state reading achievement. However, it is reasonable to think that appropriately developed spelling knowledge and sight-word reading skills would be necessary to productively engage in the close reading of text on these two assessments. The present study highlights the importance of efficient end-of-Grade 3 orthographic and reading fluency abilities to the attainment of proficient status on a state reading assessment. It is also important to remember these skills or competencies are “foundational” to reading comprehension, meaning they form the basis for higher level literacy development and cannot be overlooked or under-developed in deference to a singular focus on reading comprehension. Our results align with those of Valencia and Buly (2004), who found that well over half of students who performed poorly on state-mandated assessments of general reading achievement manifested difficulties in one or more foundational reading competencies. Our logistic binary regression analysis revealed that students achieving foundational skills proficiency had a likelihood of 6.94 of also reaching proficiency on the state reading assessment. While we cannot extend our results beyond reading achievement, a study by Paige (2011) found that middle school students with adequate foundational skills were much more likely to comprehend well and were highly likely to achieve proficiency on the end-of-year state accountability test.

### Teaching implications

Our results show that spelling knowledge has a direct effect on every variable in the model and emphasizes how critical it is that students have a deep understanding of letter-sound correspondences. This finding supports that teachers may benefit from a deep understanding of the instructional knowledge and techniques required to assist students in letter-sound acquisition. Our data also point out the critical importance of students possessing letter-sound correspondence capabilities that are near the end of the within-word stage by the end of Grade 3. Our criteria for this knowledge was a score of 9 on the DSI (Ganske, 2014). The mean DSI score for students not K-PREP proficient was 7.0, while those attaining proficiency had a mean equal to 11.1. This finding adds further support that teachers

must have instructional knowledge spanning beyond the within-word stage of the developmental spelling continuum if they are to facilitate appropriate spelling development in their students. Similar differences were seen in reading fluency where the mean accumaticity score (WCPM) for nonproficient students was 65.4 (15th percentile) whereas those who were K-PREP proficient had a mean of 104.6 (50th percentile). Our results suggest that letter-sound correspondence as measured through spelling development and reading fluency go hand in hand and that one cannot be ignored at the expense of the other if students are to have the reading skills necessary for state reading achievement.

### Conclusion

The results of our study link the importance of orthographic knowledge and fluent reading development to success on high-stakes tests of reading achievement. Our reading improvement initiative partnered university faculty with district leaders and teachers to develop a capacity-training process focused intensely on the teaching and acquisition of orthographic knowledge. Through the adoption of an “open mindset,” teachers gradually acquired new perspectives rooted in measurement, knowledge, instruction, and student results. Such thinking began with kindergarten instruction in phonological or phonemic awareness that then led to basic letter-sound instruction. In Grades 1–3 students were instructed in letter-feature knowledge using a developmental spelling approach based on a specific scope and sequence. Additionally, reading fluency instruction at the whole-class, small group, and independent levels helped students to internalize letter-sound correspondence knowledge through practice with connected text. Our results advance the idea that achievement in foundational skills leads to increased orthographic knowledge and reading fluency that is then likely to result in proficiency on the state-administered reading accountability assessment.

### Limitations

We did not employ randomized student selection and did not compare growth on the measured variables to a control group. These factors should be kept in mind when interpreting the results. While our results show that failure to reach proficiency on the foundational skills measured in the study resulted in the lower likelihood that state proficiency would occur, proficiency on these skills is not an absolute certainty of proficiency on the state reading assessment. One should also keep in mind that other explanatory factors not measured in this study may exist that are either responsible for, or enhance, the probability of obtaining a proficient score on the state reading assessment.

### Future research

Third-grade students were the sole focus of this study. Of further interest would be the extent to which the variables in this study predict state reading achievement performance in Grades 4 and 5. Because this study focused on foundational skills, other variables that may have predictive value were not assessed in the study population. These variables could include those such

as close reading skills, vocabulary knowledge, specific comprehension skills such as inferencing, ability to identify the main idea and find supporting details, and higher order or critical thinking skills. Other researchers may investigate the influence of the variables assessed in this study in children from backgrounds other than those under investigation here.

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