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Kindergarten and first grade teachers' content and pedagogical content knowledge of reading and associations with teacher characteristics at rural low-wealth schools

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HIGHLIGHTS

- Content knowledge and pedagogical content knowledge of reading can be distinguished.
- Content knowledge and pedagogical content knowledge did not vary substantially.
- Years of experience is significantly related to teacher knowledge.
- Rural teachers' experience can be used as a leverage point to enhance knowledge.
- Experiential learning components appear important in teacher education programs.

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ABSTRACT

Although often assessed as one construct, teachers have been shown to draw on both content and pedagogical content knowledge as they teach reading. Factor analysis on sixty-six primary teachers in rural low-wealth districts illustrated that teacher knowledge of reading can be distinguished separately as content and pedagogical content knowledge, with teachers having roughly equal levels of knowledge across domains. Multiple regression analyses demonstrated teaching experience was the only teacher characteristic to be significantly associated with both domains of teacher knowledge, implicating the necessity of increasing experiential learning components in teacher education.

1. Introduction

Knowledge alone is not sufficient for effective reading instruction; yet, knowledgeable teachers are necessary to help children become proficient readers (Darling-Hammond & Bransford, 2007; Darling-Hammond, 2000a; Piasta, Connor, Fishman, & Morrison, 2009; Risko et al., 2008). Some of the impetus for preparing more knowledgeable teachers for the classroom is due to findings that only 36% of students in the United States are proficient in reading by fourth grade (National Center for Education Statistics, 2015), with this percentage even lower for students living in high-poverty rural areas (24%; National Center for Education Statistics, 2015). The 'Peter Effect,' the principle that teachers cannot teach what they do not themselves know, is spurring many states to recognize the need to recruit and retain highly-knowledgeable teachers (Applegate & Applegate, 2004; Binks-Cantrell, Washburn, Joshi, & Hougen, 2012; Moats, 2014). As such, more states are requiring preservice teachers to demonstrate knowledge of reading on licensure exams (Rowland, 2015). Although the content and format of licensure exams varies, they generally assess proficiency of reading and writing development and instructional decision-making; thereby, capturing what are arguably separate domains: *content knowledge*, knowledge of the subject matter, and *pedagogical content knowledge*, knowledge of how to teach the subject matter (Shulman, 1986).

Despite the importance placed on teacher knowledge, little is known about the distinction between these domains. Researchers

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have generally measured content and pedagogical content knowledge as one construct, even though evidence indicates that they may be separate domains of knowledge (McCutchen et al., 2002; Moats, 1994; Piasta et al., 2009). This conflation has led to a limited understanding of how each domain may depict unique aspects of teacher knowledge. Furthermore, a limited body of research has examined how teacher characteristics, such as teacher qualifications, may be associated with content and pedagogical content knowledge of reading, particularly among rural teachers who may have different training and experiences compared to urban and suburban teachers (Monk, 2007). This study sought to examine whether the assessment of kindergarten and first grade teachers' knowledge of reading in rural low-wealth districts could be measured as separate domains of content knowledge and pedagogical content knowledge. Furthermore, given the theoretical importance of these constructs (Shulman, 1986), teachers' characteristics of reading methods courses, education level, and teaching experience were associated with each domain to understand how potentially malleable characteristics of teachers might influence how they acquire knowledge of reading. The current study contributes to recommendations for how pre-service teacher education and in-service professional development programs might enhance teacher knowledge of reading, particularly in low-resourced rural areas. In the remainder of this introductory section, we describe (a) the content and pedagogical content knowledge required for teaching early reading and how they affect instruction, as well as the history of research in this area; (b) how teacher knowledge has been proposed to be related to teacher qualifications in previous studies, and theoretical reasons for these associations; and (c) the importance of this study for teachers in rural low-wealth settings.

1.1. Content knowledge and pedagogical content knowledge

For several decades, researchers have proposed that various domains of teacher knowledge exist, and that teachers draw on varying aspects of knowledge to support student learning (Ball, Thames, & Phelps, 2008; Shulman, 1986). Within early reading, content knowledge (knowledge of the subject matter) and pedagogical content knowledge (knowledge of how to teach the subject matter) have predominately been investigated (McCutchen et al., 2002; Moats, 1994; Piasta et al., 2009). Content knowledge in early reading includes basic linguistic concepts, such as the ability to manipulate phonemes (smallest unit of sound, e.g.,/b/); understanding of the relationships among word structure (the admissible formation of words), syntax (grammatical rules of sentence structure), and semantics (the meaning of a word, phrase, sentence, or text); and the ability to explain text organization (how a text is structured; International Dyslexia Association, 2010; International Reading Association, 2007, 2010; McCutchen & Berninger, 1999). Pedagogical content knowledge for early reading instruction includes the possession of multiple decoding and comprehension instructional strategies, knowledge of how best to design instruction, as well as an understanding of the most appropriate ways to respond to student misunderstandings (International Dyslexia Association, 2010; International Reading Association, 2007, 2010). Although teacher knowledge is proposed to be comprised of these domains, research on teacher knowledge of early reading often treats knowledge as one construct (McCutchen et al., 2002a,b; Moats, 1994, 1999; Moats & Foorman, 2003; Piasta et al., 2009). Teacher knowledge regarding early reading is likely multifaceted; yet, there are no known empirical investigations of the domains composing teacher knowledge of early reading and how these may be differentially predicted by various teacher characteristics. Improved understanding of what constitutes teacher knowledge of reading could lead to a better understanding of the ways in which knowledge may matter for early reading.

1.2. Knowledge of early reading

Teaching early reading requires unique content and pedagogical content knowledge (Moats, 2009). Teachers need to understand the developmental progression of literacy and have the ability to make an internal process tangible for young students (Allington, 2013). A concept that is frequently difficult for both students and teachers is phonological awareness, including its subordinate component, phonemic awareness. Phonological awareness is the recognition that words are made up of a variety of sound units, including syllables (part of a word that contains a single vowel sound and that is pronounced as a unit), onsets (the part of the syllable preceding the vowel), rimes (the part of the syllable consisting of its vowel and any consonant sounds that come after it), and phonemes (the smallest unit of sound, e.g.,/b/). Effective teachers have highly-developed phonological awareness, understand that children's phonological awareness and especially phonemic awareness is a critical precursor before understanding the sound/symbol relationships in reading English words, and possess instructional strategies that help young students develop phonological awareness (Gillon, 2018; Snow, Burns & Griffin, 1998). Phonological awareness enables students to segment and blend syllables, onsets, and rimes, and to identify and produce rhymes, which have been associated with early reading skills (Adams, 1990; Gellert & Elbro, 2017). Without phonological awareness, students are not able to segment and blend sounds to decode and encode words. Although phonological awareness does not explicitly relate to students' learning of sound/symbol relationships, phonics (a method of teaching reading by associating sounds with letters) focuses on these important letter-sound correspondences (Adams, 1990). Both phonological awareness and phonics instruction, along with efforts to improve students' oral language, vocabulary, fluency, and comprehension skills, can be considered important aspects of what teachers need to know when teaching reading (Allington, 2002). Teachers must be able to identify the most appropriate instructional need (content knowledge) and to provide appropriate instruction that targets that need (pedagogical content knowledge).

On a range of assessments designed to measure classroom teachers' knowledge of early reading, teachers have been able to answer as few as 32% of items (Moats, 1994; McCutchen et al., 2002), and as many as 68% (Bos, Mather, Dickson, Podhajski, & Chard, 2001; McCutchen et al., 2002). Across studies, many teachers exhibited misunderstandings of the content of reading (Cohen, Mather, Schneider, & White, 2017; Crim, Hawkins, Thornton, Boon Rosof, Copley, & Thomas, 2008; Cunningham, Etter, Platas, Wheeler, & Campbell, 2015; Stark, Snow, Eadie, & Goldfeld, 2016; Tetley & Jones, 2014; Washburn, Joshi, & Binks-Cantrell, 2011). These misunderstandings included a lack of knowledge of terminology (e.g., *phonics*, *phoneme*); gaps in teachers' own phonological awareness, such as not being able to segment phonemes accurately; and mistook teaching *phonological awareness* with teaching *letter-sound correspondences*. Teachers also exhibited misunderstandings about the relationship between listening and reading comprehension, the appropriateness of particular instructional strategies, and an inability to make appropriate pedagogical decisions when presented with student responses (e.g., selecting instructional strategies focused on comprehension when presented with student responses indicating phonics instruction was necessary). Similar findings of teachers' low reading content knowledge have been found in international settings (Aro & Björn, 2016; Zhao, Joshi, Dixon, & Huang, 2016). The reasons why early elementary classroom teachers are largely unable to answer most reading-related

questions correctly across research studies remains unclear. Certain teacher characteristics, such as reading methods courses, education level, and teaching experience, have been proposed to relate to early elementary classroom teachers' reading knowledge (Buddin & Zamarro, 2009; Clotfelter, Ladd, & Vigdor, 2007; Darling-Hammond, 2000b; Harris & Sass, 2011; Wayne & Youngs, 2003), but the nature of these relationships are not yet well understood.

1.3. Characteristics associated with teacher knowledge of reading

Understanding how teachers acquire knowledge regarding early reading is critical so teacher education programs and in-service professional development programs can optimize their impact (Cunningham & O'Donnell, 2015). In the current study, malleable teacher characteristics that are proposed to lead to greater knowledge of reading include reading methods courses, education level, and teaching experience. Although most studies have related these teacher characteristics to student outcomes (Buddin & Zamarro, 2009; Clotfelter et al., 2007; Darling-Hammond, 2000b; Harris & Sass, 2011; Wayne & Youngs, 2003), less empirical work has focused on how teacher characteristics are related to their knowledge of reading.

Nonetheless, the relationships between teacher characteristics and knowledge of reading are conceptually supported. For example, teachers who have advanced degrees may be more knowledgeable than their peers with Bachelor's degrees, as an advanced degree is indicative of increased time spent gaining knowledge (Buddin & Zamarro, 2009; Clotfelter et al., 2007; Darling-Hammond, 2000b; Harris & Sass, 2011; Wayne & Youngs, 2003). For the same reason, teachers who have taken more courses related to reading methods may have increased knowledge given the additional time devoted to increasing their knowledge in a particular area. Indeed, content-specific coursework may have a better relationship with teacher knowledge than educational level. Although an advanced degree represents elective courses and general education requirements, the number of reading methods courses are specifically relevant to reading instruction (Croninger, Rice, Rathbun, & Nishio, 2007; Darling-Hammond, 2000b; Harris & Sass, 2011; Wayne & Youngs, 2003). Finally, teaching experience may also be related to knowledge given the experiential component of learning (Kolb, 1984). Kolb posited a four-stage learning cycle during which individuals first have an experience, reflect on the experience, learn from the experience, and then implement what they have learned. Transaction between the person (i.e., teacher) and the environment (i.e., classroom) is necessary for learning (i.e., how to effectively teach reading). For teachers, these experiences interacting with students in their classrooms, which accumulate over time spent teaching, may increase teachers' knowledge of reading.

In one of only two known studies to examine teacher characteristics and teacher knowledge of reading, Piasta et al. (2009) examined correlations of teacher knowledge (measured as a combination of content knowledge and pedagogical content knowledge) with the possession of a Master's degree, total years of experience, and years of experience teaching first grade with a sample of forty-two first grade teachers in the Southeast. They found that teacher knowledge of reading was not related to possession of a Master's degree. Instead, teacher knowledge of reading was positively correlated with years teaching first grade ($r = .41$), implying that experience may contribute uniquely to teachers' knowledge of reading. However, the other known study (Hammond, 2015) found no significant relationship between teaching experience and knowledge. Yet, unlike the study by Piasta and colleages, the teachers in the Hammond study were overall very experienced teachers, which may have accounted for the lack of relationship. Clearly, research is needed in this area using more sophisticated data analysis techniques to determine whether teaching experience and teacher knowledge are related.

1.4. Rural context

The current study was situated in rural low-wealth school districts, which has been an under-investigated setting in previous studies of teacher knowledge, which have predominately focused on urban and suburban teachers (Bos et al., 2001; Cunningham, Perry, Stanovich, & Stanovich, 2004; Foorman et al., 2006; McCutchen et al., 2002; Piasta et al., 2009). Rural teachers' knowledge of teaching reading is critical to understand because both No Child Left Behind (NCLB, 2002) and the Every Student Succeeds Act (ESSA, 2015) require states to ensure there is no disparity in the number of effective teachers in communities across geographic locations. Nonetheless, several studies have highlighted differences in teacher quality across communities (Lee & Burkam, 2002; Provasnik et al., 2007; Vernon-Feagans, Kainz, Hedrick, Ginsberg, & Amendum, 2013). For example, teachers in rural low-wealth communities tend to be less educated than their urban and suburban counterparts, although they have more years of experience (Amendum, Vernon-Feagans, & Ginsberg, 2011; Darling-Hammond, 1997). These differences may be attributable to the geographic isolation of many rural low-wealth areas. Geographic isolation is associated with diminished access to professional development, higher education, and technology, which can all impact the knowledge level of teachers in rural low-wealth areas (Duncan, 1999; Provasnik et al., 2007) and may be indicated in rural students' lower reading proficiency (National Center for Education Statistics, 2015).

1.5. The current study

This current study builds on the significant contributions of Shulman's (1986) delineation of domains of teacher knowledge by attempting to measure content knowledge separately from pedagogical content knowledge. Few studies have examined the relationship between teacher characteristics and teacher knowledge, and none of those studies have occurred in rural low-wealth contexts. Understanding how reading methods courses, education level, and teaching experience relate to teacher knowledge may allow for an increased emphasis by preservice and inservice programs to promote increased opportunities for teachers to build on the areas found to be most related to teacher knowledge. As such, this study addressed the following questions: (1) Can content knowledge and pedagogical content knowledge be assessed separately? We hypothesize that the two domains can be separately assessed given their important theoretical and conceptual differences (Shulman, 1986). (2) What is the level of teacher content and pedagogical content knowledge among kindergarten and first grade classroom teachers in rural low-wealth schools? Although differences exist between rural and urban teachers, we nonetheless hypothesize that teacher content and pedagogical content knowledge levels will be roughly equivalent to those found in previous studies (Bos et al., 2001; Moats, 1994; McCutchen et al., 2002). (3) How do number of reading methods courses, education level, and teaching experience relate to teacher knowledge? Finally, we hypothesize that teacher content and pedagogical content knowledge will be positively related to reading methods courses and teaching experience given conceptual relationships and limited previous work in this area (Hammond, 2015; Piasta et al., 2009).

2. Methods

This study used data from a randomized controlled trial (RCT)

studying the effects of the Targeted Reading Intervention (TRI; Vernon-Feagans et al., 2012, 2013). TRI is a professional development program for classroom teachers that uses webcam coaching to enhance the reading outcomes of kindergarten and first grade students. The RCT was conducted in rural eastern NC with teachers in Title I schools, which served a high percentage of children from low-income families. Schools included in this study had a range of 30–96% of students receiving free- or reduced-price lunch and served 22–96% of minority students.

2.1. Sample

Because the TRI is a professional development program designed to improve teachers' knowledge and teaching of reading, the current study used data from the control teachers to avoid a counfound with TRI treatment. The inclusion of only control group teachers yielded a sample size of 66 teachers assigned to the control condition with no missing data on any variables of interest. Teachers in the control condition received a laptop or iPad and a computerized math curriculum known as Building Blocks (Clements & Sarama, 2007), but did not receive any reading materials, training, or coaching. The provision of a math curriculum was not anticipated to affect the findings of the current study, as analyses were restricted to reading knowledge. In addition to receiving the laptop/iPad and math curriculum, control teachers were also compensated $50 for questionnaire completion.

2.2. Procedures

Teachers completed questionaries about their knowledge of reading and demographic data in the fall and spring of each study year. Teachers were provided with web links to complete the surveys. If teachers were not able to access the web-based surveys, paper copies were provided.

2.3. Measures

The Teacher Knowledge Survey and the teacher questionnaire, which measured demographic characteristics, were the two measures used in the current investigation.

Teacher Knowledge Survey (TKS). The TKS (Moats, 1994; Piasta et al., 2009) included a sequence of questions designed to assess teachers' knowledge about the teaching of reading (see Appendix A). It took an average of fifteen to twenty minutes to complete and was composed of true/false and multiple choice items based on previous research of teacher knowledge (Moats, 1994; Piasta et al., 2009). The seven true/false items on the TKS were created by Moats (1994). The theoretical intent of these items was “to assess the knowledge teachers have of speech sounds, their identity in words, correspondence between sounds and symbols, concepts of language, and presence of morphemic units in words” (p. 89). The theoretical constructs intended to be assessed by the twenty-five multiple choice items developed by Piasta et al. (2009) were “teachers' understanding of English phonology, orthography, and morphology, as well as important concepts of literacy acquisition and instruction” (p. 232). Together, the two sections were developed to assess the foundational aspects of the structure of written English, which the field has determined is important for effective early reading instruction (e.g., McCutchen et al., 2002; McCutchen et al., 2002; Moats & Foorman, 2003; Piasta et al., 2009). In addition, the Piasta et al. (2009) questions were also intended to measure the concepts underlying effective reading instruction, such as teachers' ability to respond to vignettes depicting early reading instructional scenarios.

For each item, responses were coded as correct (1) and incorrect (0). Correct responses to all true/false and multiple-choice items were then summed to create the composite variable, *overall knowledge*. For the current sample, the TKS *overall knowledge* composite had a Cronbach's alpha of .78. Although the total possible range of scores of *overall knowledge* was 0–32, the mean *overall knowledge* score for this sample was 17.66 ($SD = 4.46$), with a range of 6–24.

Teacher questionnaire. The teacher questionnaire included questions about teachers' educational background, including reading methods courses, education level, and teaching experience. *Reading methods courses* was measured as a continuous variable and had a mean of 3.45 ($SD = 1.78$), with a range of 0–6. *Education level* was measured as a binary variable where possessing a Bachelor's degree was dummy coded as 0 and possessing a Master's degree was dummy coded as 1. Over one-quarter of teachers (28%) possessed a Master's degree, while the remaining teachers possessed a Bachelor's degree. To report total years of teaching experience, teachers were asked to respond to the closest half year. *Teaching experience* was measured as a continuous variable and had a mean of 8.75 ($SD = 8.49$), with a range of 0–32 years.

Control variables. For regression analyses, teacher *age*, *race*, and *grade* were used as control variables representing less malleable teacher characteristics that may nonetheless influence their knowledge of reading and teaching reading. Teacher *age* was coded as a continuous variable in years. Teachers were asked to report their year of birth as well as the date they completed the questionnaire. Age was calculated using year of completion of the questionnaire and year of birth. For this sample, the mean age was 36.17 ($SD = 10.10$), with a range of 22–59 years. Teacher *race* was recorded in six categories: (a) American Indian or Alaska Native, (b) Asian, (c) Black or African American, (d) Native Hawaiian or Other Pacific Islander, (e) White, and (f) other. Teachers who responded “other” were asked to specify the race with which they identified. For this sample, no teachers responded “other.” Only one respondent (1.52%) identified as an American Indian or Alaska Native, 21.21% of the sample identified as Black or African American, and 77.27% identified as White. Given the small number of respondents who neither identified as Black/African American or White, race was dummy coded to represent White = 0 and minority = 1. *Grade* was dummy coded to represent kindergarten = 0 and first grade = 1. Descriptive information about the teachers can be seen in Table 1.

2.4. Analysis plan

All analyses were completed in SAS 9.2, with the exception of the factor analysis of the teacher knowledge items, which was completed in MPlus 7. Before beginning this study, univariate statistics were examined to analyze means, standard deviations, and ranges to ensure the reasonableness of the data. No unexpected values were found. Based on that preliminary examination, a confirmatory factory analysis (CFA) was conducted on the TKS to

Table 1
Teacher demographics (N = 66).

Variable	% or *M*	*SD*
Gender (0 = male, 1 = female)	98.48	
Race (0 = minority, 1 = white)	77.27	
Age	36.17	10.10
Grade (0 = kindergarten, 1 = first grade)	54.54	
Education Level (0 = Bachelor's only, 1 = Master's)	28.80	
Teaching Experience	8.75	8.49
Reading Method Courses	3.45	1.78

empirically determine the underlying domains of teacher knowledge measured by this assessment. Given the emphasis on content knowledge and pedagogical content knowledge in previous research as well as by teacher education accreditation programs (Council for the Accreditation of Educator Preparation, 2016; McCutchen et al., 2002; Moats, 1994; Piasta et al., 2009), CFA was conducted to confirm whether these items were empirically assessing these two factors. Items were first divided into the two conceptual groups under investigation: (a) items measuring knowledge of reading and (b) items measuring knowledge of teaching reading. While the authors of the measures did not originally define each item as such, they did specify that they anticipated items to measure content knowledge or pedagogical content knowledge (Moats, 1994; Piasta et al., 2009).

Items capturing content knowledge included the following: understanding of linguistics (e.g., *Which word contains a short vowel sound*; item 12), understanding of assessment terms (e.g., *What type of task would this be? I am going to say a word and then I want you to break the word apart. Tell me each of the sounds in the word* dog; item 15), theoretical understanding of reading development (e.g., *Students must be able to orally segment and blend the phonemes in complex syllables before they can benefit from instruction in letter-sound correspondence*; item 1), and ability to apply knowledge of reading separately from instruction (e.g., *Circle the word that is a real word when you sound it out*; item 33). Items capturing pedagogical content knowledge included the following: vignettes of instructional scenarios for which teachers selected the best response to achieve a stated goal (e.g., *Mrs. Pink has assigned her students a short story to read independently. She wants to practice a strategy with her students in order to enhance their comprehension during reading. Mrs. Pink should instruct her students to* ____; item 23), identification of instructional activities designed to meet particular goals (e.g. *One example of an activity that teachers can use to assist with multi-strategy instruction is* _____; item 29), and demonstration of understanding of evidence-based instructional methods (e.g., *According to research, the least effective way to teach vocabulary to students is through the use of* _____; item 22). All items can be seen in Appendix A.

To confirm the theoretical domains of content knowledge and pedagogical content knowledge in the TKS, the model was first estimated using a weighted least squares means and variance adjusted (WLSMV) estimator, given the dichotomous nature of the variables under study. Then, the model fit was assessed using the chi-square test of model fit, the root mean square error of approximation (RMSEA), the comparative fit index (CFI), and the Tucker-Lewis index (TLI). To answer subsequent research questions, maximum a posteriori (MAP) factor scores were created in MPlus7 for both the content knowledge factor and the pedagogical content knowledge factors.

Hierarchical multiple regressions were then used to examine the relationship between teachers' reading methods courses, education level, and teaching experience, and *overall knowledge*, *content knowledge*, and *pedagogical content knowledge*. Six regression analyses were conducted predicting to overall knowledge, content knowledge, and pedagogical content knowledge, with each outcome of teacher knowledge examined separately, given the potential collinearity issues. The first model in each regression contained only the control variables (age, race, and grade), and the

Table 2
Initial CFA divided by content knowledge and pedagogical content knowledge items.

Item	R^2 estimate	Residual variance
Content knowledge		
Item 30	0.90	0.10
Item 31	0.77	0.23
Item 13	0.75	0.26
Item 32	0.69	0.31
Item 14	0.55	0.45
Item 12	0.55	0.45
Item 1	0.53	0.47
Item 9	0.44	0.56
Item 2	0.38	0.62
Item 33	0.30	0.70
Item 10	0.16	0.84
Item 6	0.14	0.86
Item 3	0.12	0.88
Item 11	0.12	0.88
**Item 8	0.09	0.91
**Item 7	0.05	0.96
**Item 16	0.03	0.97
**Item 5	0.02	0.98
**Item 4	0.02	0.98
**Item 17	0.00	0.99
Pedagogical content knowledge		
Item 19	0.84	0.16
Item 21	0.60	0.40
Item 18	0.60	0.40
Item 27	0.52	0.49
Item 28	0.39	0.62
Item 15	0.27	0.73
Item 20	0.26	0.74
Item 23	0.24	0.76
Item 26	0.23	0.77
Item 24	0.15	0.85
**Item 29	0.10	0.90
**Item 22	0.09	0.91
**Item 25	0.02	0.99

Note. ** indicates items that were removed.

second model in each regression contained both the control variables and variables of interest (reading methods courses, education level, and teaching experience). The issue of potential teacher nesting was considered. However, given only ten schools, accounting for nesting led to convergence issues (Bell, Morgan, Kromrey, & Ferron, 2010). For each model, the *F*-statistic and the change in R^2 were examined, while the *B* coefficients were examined for each variable of interest separately. Effect sizes were calculated for all significant findings using Cohen's *d* (Cohen, 1988).

3. Results

3.1. Confirmatory factor analysis findings

After creating a model based on the conceptual delineation between content knowledge and pedagogical content knowledge (Moats, 1994; Piasta et al., 2009; Shulman, 1986), the model was estimated using WSLMV and the fit indices were examined (see Table 3). Initial examinations of the fit indices, when considered overall, indicated the fit was marginal. A chi-square test of goodness-of-fit indicated the model fit well, χ^2 (494) = 536.52, $p = 0.09$. However, RMSEA provided an estimate of 0.04 with a 90% CI [0.00, 0.06], and the probability that the RMSEA ≤ .05 = 0.86. Finally, CFI = 0.90 and TLI = 0.89. Overall, these fit indices indicated this initial model could fit better. When examining the R^2 values of each item, many were below 0.10, indicating the model was explaining less than 10% of the variance in these items. The items with R^2 values of less than 0.10 were removed from the model, as low R^2 values can be an indication of high levels of error for these items (Hooper, Coughlan, & Mullen, 2008). These items may not have loaded well to the domains of content knowledge and pedagogical content knowledge because they were assessing another domain of teacher knowledge not yet researched in early reading, or they may have not been accurately assessed by the current sample. For example, one question that did not load to either domain assessed reading content that is frequently not taught by kindergarten and first grade teachers. The R^2 values for each item in this model can be seen in Table 2, with the items divided by content knowledge and pedagogical content knowledge.

Subsequently, the two-factor (content knowledge and pedagogical content knowledge) model was rerun with fourteen content knowledge items and ten pedagogical content knowledge items. As before, a WLSMV estimator was used. A chi-square test of goodness-of-fit indicated the model fit well, χ^2 (251) = 267.63, $p = 0.23$. Moreover, RMSEA provided an estimate of 0.03 with a 90% CI [0.00, 0.06], and the probability that the RMSEA ≤ .05 = 0.83. Finally, CFI = 0.96 and TLI = 0.96. The two-tailed *p*-values for each item loading onto its designated factor were all below 0.05. Overall, these fit indices indicated this model fit well, and better than the model with all items included. Therefore, the TKS measure confirmed by CFA, which excluded nine items, appeared to be composed of two factors measuring content knowledge and pedagogical content knowledge. Based on CFA results, factor scores were created in MPlus to be used as outcomes in regression analyses and composite scores were created in SAS using the 24 included items to examine subsequent research questions.

Table 3
Goodness of fit indices for alternative confirmatory factor analysis models (N = 66).

Model (no. factors)	χ^2	*df*	*p*	RMSEA	CFI	TLI
All items (2)	536.52	494	.09	.04	.90	.89
Items above r-squared of .10 (2)	267.63	251	.23	.03	.96	.96

3.2. Correlation findings

Rural kindergarten and first grade classroom teachers in this study answered 71.02% of all items correctly. They were able to answer 71.65% of content knowledge items correctly, and 70.15% of pedagogical content knowledge items. Thus, their levels of knowledge did not vary substantially across factors. The correlations among variables can be seen in Table 4 for all variables. Each of the knowledge variables was highly correlated. Additionally, race was significantly correlated with each of the knowledge variables and age was significantly correlated with education level and teaching experience, substantiating their inclusion as control variables.

3.3. Regression findings

Overall knowledge. The overall knowledge model, controlling for teacher age, race, and grade, was non-significant, $F(3, 59) = 2.59$, $p = 0.06$. After adding the variables of interest, teaching experience was significantly associated with overall knowledge ($B = 0.22$, $p = 0.02$) and had a large effect size ($d = 0.61$). The other variables of interest were not significantly associated with overall knowledge (reading methods courses, $B = -0.46$, $p = 0.17$; and education level, $B = 1.09$, $p = 0.38$). As a whole, the variables of interest increased the R^2 by 11%.

Content knowledge. The content knowledge model, controlling for teacher age, race, and grade, was non-significant, $F(3, 59) = 2.29$, $p = 0.09$. After adding the variables of interest, teaching experience was significantly associated with content knowledge ($B = 0.05$, $p = 0.01$) and had a large effect size ($d = 0.64$). The other variables of interest were not significantly associated with content knowledge (reading methods courses, $B = -0.08$, $p = 0.30$; and education level, $B = -0.07$, $p = 0.80$). As a whole, the variables of interest increased the R^2 by 10%.

Table 4
Correlation matrix (N = 66).

Variable	1	2	3	4	5	6	7	8	9
1. Teacher knowledge	1.00	–	–	–	–	–	–	–	–
2. Content knowledge	0.88**	1.00	–	–	–	–	–	–	–
3. PCK	0.89**	0.96**	1.00	–	–	–	–	–	–
4. Reading methods courses	−0.07	0.00	0.00	1.00	–	–	–	–	–
5. Education level	0.04	−0.05	−0.06	0.21	1.00	–	–	–	–
6. Teaching experience	0.08	0.18	0.18	0.35**	0.16	1.00	–	–	–
7. Age	−0.18	−0.05	−0.05	0.26*	0.11**	0.71	1.00	–	–
8. Race	0.29*	0.28*	0.30*	0.14	−0.21	−0.10	−0.25	1.00	–
9. Grade	0.01	0.05	0.05	0.14	0.24	−0.08	−0.16	−0.06	1.00

Note. *$p < .05$, **$p < .01$, ***$p < .001$.

Pedagogical content knowledge. The pedagogical content knowledge model, when controlling for teacher age, race, and grade, was also non-significant, $F(3, 59) = 2.19$, $p = 0.10$. Teaching experience was significantly associated with pedagogical content knowledge ($B = 0.05$, $p = 0.01$) and had a large effect size ($d = 0.62$). The other variables of interest were not significantly associated with pedagogical content knowledge (reading methods courses, $B = -0.07$, $p = 0.32$; and education level, $B = -0.07$, $p = 0.81$). As a whole, the variables of interest increased the R^2 by 9%. Regression results can be found in Table 5.

4. Discussion

The aim of this study was to examine the factor structure of the Teacher Knowledge Survey (TKS; Moats, 1994; Piasta et al., 2009), teachers' level of knowledge on the identified factors, and the relationships between reading methods courses, education level, teaching experience, and knowledge of reading. This study found the following, which will be discussed in more detail below: (1) The TKS (Moats, 1994; Piasta et al., 2009), a questionnaire with thirty-three items, was demonstrated to be composed of domains of content knowledge and pedagogical content knowledge when nine of the items were removed. (2) On each of these domains and on the overall measure, teachers answered approximately 70% of questions correctly. (3) Teaching experience was the only teacher characteristic that was significantly associated with overall knowledge, content knowledge, or pedagogical content knowledge on the TKS. Reading methods courses and education level were not significantly associated with any measure of teacher knowledge.

4.1. Composition of teacher knowledge of early reading

Teacher knowledge was assessed using the TKS, which was comprised of items created by Moats (1994) and Piasta et al. (2009). For the current sample of teachers in rural low-wealth school districts, the TKS, as confirmed by CFA analyses, appeared to separately assess domains of content knowledge and pedagogical content knowledge as proposed by Shulman (1986). Interestingly, the items developed by Moats (1994) only loaded to content knowledge. In contrast, the items developed by Piasta et al. (2009) loaded to both content knowledge and pedagogical content knowledge. This difference may represent a more recent understanding of the importance of pedagogical content knowledge acknowledged by reading researchers and practitioners (Bos et al., 2001; Kelcey, 2011; McCutchen et al., 2002). These domains have been theoretically proposed and posited to be critical for teachers (Shulman, 1986), but have not previously been empirically demonstrated as separate domains when studying knowledge of reading and teaching reading. This study represents the first known empirical demonstration that content knowledge and pedagogical content knowledge can be independently measured. Since it is possible to measure one without the other, and both are important for effective teaching, it is important we ensure the current knowledge assessments often required for licensure assess each of these domains and do not neglect one or the other. Given that content and pedagogical content knowledge can be independently assessed, future studies can explore the relationships between the domains of teacher knowledge and other variables of interest, thereby expanding the field's knowledge on the importance of teacher knowledge. Improved discernment of what constitutes teacher knowledge of reading could lead to a better understanding of the ways in which knowledge may affect early reading instruction and student learning.

4.2. Levels of teacher knowledge of early reading

The overall level of teacher knowledge among kindergarten and first grade classroom teachers in rural low-wealth schools in this sample was 71%. That is, teachers in this sample were able to answer 71% of the items on the TKS correctly on average (72% of the content knowledge items and 70% of the pedagogical content knowledge items). This level of knowledge is higher than what has been reported in other studies conducted with early elementary teachers in non-rural low-wealth environments (Bos et al., 2001; Mather, Bos, & Babur, 2001; McCutchen et al., 2002a,b; Moats & Foorman, 2003; Piasta et al., 2009). Given the finding in this study that experience was the only teacher characteristic to be significantly associated with teacher knowledge, as well as previous research indicating rural teachers tend to have more experience than urban and suburban teachers (Amendum et al., 2011; Goldring, Gray, & Bitterman, 2013; Player, 2015), these teachers' experience may have allowed them to demonstrate a higher level of knowledge than what has been previously observed in non-rural samples. This finding could provide a leverage point for professional development in rural areas to capitalize on the teachers' experience and use it as a catalyst for change. Professional development in rural areas could begin by determining the experiences of the attending teachers, relate those experiences to the topic under study, and induce the buy-in and investment of the teachers to propel change and induce their use of the practice. This differs from what most commonly occurs in one-size-fits-all professional

Table 5
Regressions examining teacher characteristics and overall knowledge, content knowledge, and pedagogical content knowledge (N = 66).

Variables	Overall Knowledge		CK		PCK	
	B	*SE*	*B*	*SE*	*B*	*SE*
Model One						
Race	3.01*	1.35	0.67*	0.31	0.71*	0.31
Grade	−0.04	1.11	0.18	0.25	0.17	0.25
Age	−0.17*	0.08	−0.02	0.02	−0.02	0.02
R^2	0.09		0.08		0.09	
Model Two						
Reading Courses	−0.46	0.33	−0.08	0.07	−0.07	0.07
Education	1.09	1.24	−0.07	0.28	−0.07	0.28
Experience	0.22*	0.09	0.05*	0.02	0.05*	0.02
R^2	0.20		0.18		0.18	
F	2.59		2.29		2.19	

Note. *$p < .05$, **$p < .01$, ***$p < .001$. CK = Content Knowledge, PCK = Pedagogical Content Knowledge. Model one refers to controls only, while model two refers to control variables and variables of interest.

development sessions (Cunningham & O'Donnell, 2015; Froschauer, 2010; Waitoller & Artiles, 2013).

4.3. Teacher characteristics and teacher knowledge of early reading

Of the teacher characteristic variables measured in this study (reading methods courses, education level, and teaching experience), only teaching experience had a significant association with overall knowledge, content knowledge, and pedagogical content knowledge. The current study corroborates previous findings revealing a correlational relationship between teaching experience and teacher knowledge (Piasta et al., 2009). Importantly, it differs from the more recent findings of Hammond (2015) of no significant relationship between teaching experience and teacher knowledge. Clearly more work is needed in this area to determine how and when teaching experience impacts knowledge. Although no significant association was found between teacher education-related variables and knowledge, there are important quality dimensions of both reading methods courses and education level that were not captured in the current study. Neither the content of reading methods courses nor the type or location of pre-service training received by teachers were able to be examined as this information was not collected. These more detailed measures might be more predictive than education level and reading methods courses. Furthermore, the items removed from the TKS, and the domains to which they may load, may uniquely relate to teacher characteristics in ways content knowledge and pedagogical content knowledge do not.

Understanding that experience is associated with teacher knowledge can allow pre-service teacher education and in-service professional development to capitalize upon teachers' experience. Schools of education can build on this relationship by increasing the amount of in-school practica and internships in which pre-service teachers engage. Doing so could allow novice teachers to accumulate experience that can enhance their teacher knowledge even before beginning their formal teaching careers. It has been well noted that teacher education programs are stronger when a "learning and doing" approach is implemented (Fazio, 2003, pp. 23–45; Risko et al., 2008; Wolf, Carey, & Mieras, 1996). Similarly, relationship-based professional development, such as teacher study groups, can be used to enhance teachers' knowledge and build upon teachers' experiences rather than providing one-size-fits-all professional development (Cunningham & O'Donnell, 2015). Similarly, ways to provide practicing teachers with incentives to remain in the classroom and avoid costly attrition, such as mentoring programs, will encourage more teachers to remain in the classroom and allow their students to reap the benefits of their enhanced knowledge.

4.4. Limitations

A number of considerations must be taken into account when interpreting these findings. First and foremost, this study examined the skills needed for reading instruction without attending to the sociocultural realm of reading. Reading is much more than a skill base. It is a complex social process that requires cognitive, linguistic, and social skills. It involves abstraction, reflection, interpretation, cross-cultural understanding, and critical thinking (Gee, 1990). Skills instruction alone is frequently not sufficient when taught to the exclusion of either meaning-based instruction or socioculturally relevant instruction. Nevertheless, basic skills are necessary and comprise measurable domains of teacher knowledge, as shown in the current study.

The use of a small sample of control teachers in this research further restricts the conclusions that can be drawn because no causal relationship can be determined with non-experimental data. Therefore, we must be careful not to make causal connections as we consider implications. Similarly, given the context of rural low-wealth schools, the results found will only be generalizable to similar contexts. This context is critical, however, because previous research on early reading knowledge has not focused on rural low-wealth settings. Although the rural low-wealth context is a strength of this study, having few previous findings with which to compare these results makes interpreting them difficult.

Moreover, given the confines of this study to an existing dataset, the investigation into the domains underlying the concept of teacher knowledge is necessarily restricted to those being measured by the assessment used, the TKS. The TKS (Moats, 1994; Piasta et al., 2009) is not the only assessment of reading knowledge of early elementary classroom teachers that exists, however. Other measures of teacher knowledge may capture domains of teacher knowledge other than those captured on the TKS, such as case knowledge or strategic knowledge (Shulman, 1986).

Finally, no observations of classroom teacher's behavior or reading instruction were conducted. Therefore, no relationship between teachers' knowledge and instruction can be posited. To date, there is mixed evidence whether teacher knowledge translates directly to instructional practice (Hammond, 2015; McCutchen et al., 2002a,b; Podhajski, Mather, Nathan, & Sammons, 2009; Spear-Swerling & Brucker, 2004). This topic is an important area for future research.

5. Conclusion

Continued attention to teacher knowledge, such as the assessments being required by teacher education accreditation and teacher licensure organizations ultimately designed to support student academic achievement, necessitates better understanding of both what constitutes teacher knowledge and how it is engendered. One of the critical findings from this study is that teacher knowledge is composed of domains of content knowledge and pedagogical content knowledge, though they are highly related. Thus, assessments of teacher knowledge should attend to knowledge in both domains. The other significant finding of this study is that teaching experience is significantly related to teacher knowledge. Providing pre-service teachers with opportunities to observe and engage in experiential learning, such as supervised internships in local schools, will be important for increased knowledge. Emphasis on in-service learning opportunities is likely important, as experience was the only teacher characteristic associated with both domains and overall knowledge of reading. Furthermore, ways to provide teachers with incentives to remain in the classroom and avoid costly attrition, such as mentoring programs, continue to be critical for the success of early elementary programs. By focusing on enhancing the knowledge of our teachers and strengthening our teacher base, we will serve our students well by placing them in hands prepared to teach them.

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Appendix A. Teacher knowledge survey

Item	Domain
1. Students must be able to orally segment and blend the phonemes in complex syllables before they can benefit from instruction in letter-sound correspondence. T **F**	Content knowledge
2. If a student is "glued to print", reading slowly word-by-word, the student should be told to read faster and to stop spending so much effort to decode. T **F**	Content knowledge
3. Screening at the end of kindergarten can be efficient, reliable, and valid for predicting a child's silent passage reading comprehension at the end of third grade. **T** F	Content knowledge
4. The best remedy for a weakness in nonsense word reading is lots of practice reading nonsense words. T **F**	Content knowledge
5. Timed letter naming on DIBELS is a good risk-indicator for later reading comprehension. **T** F	Content knowledge
6. Phonological awareness exercises should always include letters or print. T **F**	Content knowledge
7. A closed syllable always begins with a consonant. T **F**	Content knowledge
8. A schwa sound is found in the word: (a) resume **(d) about** (b) bread (e) flirt (c) look	Content knowledge
9. Which word contains a short vowel sound? (a) treat (d) paw (b) start (e) father **(c) slip**	Content knowledge

10. A diphthong is found in the word: (a) coat (d) sing **(b) boy** (e) been (c) battle	Content knowledge
11. A voiced consonant digraph is in the word: (a) think **(d) the** (b) ship (e) photo (c) whip	Content knowledge
12. What type of task would this be? "I am going to say a word and then I want you to break the word apart. Tell me each of the sounds in the word *dog*." (a) blending **(c) segmentation** (b) rhyming (d) deletion	Content knowledge
13. What type of task would this be? "I am going to say some sounds that will make one word when you put them together. What does /sh/ /oe/ say?" **(a) blending** (c) segmentation (b) rhyming (d) manipulation	Content knowledge
14. Count the number of syllables for the word *unbelievable*. (a) four (c) six **(b) five** (d) seven	Content knowledge
15. For skilled readers, listening and reading comprehension are usually about equal. For developing readers in K-3, it is true that: (a) Reading comprehension is better than listening comprehension. (b) **Listening comprehension is better than reading comprehension.** (c) Reading and listening comprehension are comparable, about the same. (d) There is no systematic relationship between reading comprehension and listening comprehension.	Pedagogical content knowledge
16. How many morphemes are in the word *unbelievable*? (a) one **(c) three** (b) two (d) four	Content knowledge

17. How many morphemes are in the word *pies*? (a) zero (b) one **(c) two** (d) three	Content knowledge
18. Mr. Drake recently read two nonfiction books to his class. One of the books was about ants and the other about spiders. Which of the following tools would be most useful in allowing his students to compare and contrast the characteristics presented in the two books? (a) semantic map (b) story map (c) KWL chart (d) **Venn diagram**	Pedagogical content knowledge
19. According to research, the least effective way to teach vocabulary to students is through the use of: (a) **ask students to write definitions of new vocabulary words** (b) teach new terms in context of subject-matter lesson (c) identify examples related to the word's meaning (d) discuss synonyms for new vocabulary words	Pedagogical content knowledge
20. Mrs. Pink has assigned her students a short story to read independently. She wants to practice a strategy with her students in order to enhance their comprehension during reading. Mrs. Pink should instruct her students to: (a) ask her a question when they do not understand (b) when they come across a word that do not know, stop reading and look it up in the dictionary (c) **scan the text and prewrite questions that they want to have answered as they read** (d) write a reflection in their literacy journals immediately after reading the text	Pedagogical content knowledge
21. You plan time during your literacy block for students to engage in a reading activity that will improve fluency. Which of the following activities would be most effective in achieving this goal? (a) Students independently read a text and then answer a series of literal and inferential comprehension questions.	Pedagogical content knowledge

(b) As a whole class, each student will take a turn reading a paragraph from a text related to your current curriculum. While one student in reading, the other students listen and read along silently in their own text. (Round-robin reading) (c) **The teacher reads a passage aloud to model fluent reading and then students reread the text independently. (Guided oral reading)** (d) In pairs, students are assigned a list of words for which they are asked to write definitions and sample sentences.	
22. Ms. Jones' students say they understand the text that they are reading in their science textbooks, but they are unable to correctly answer questions about the content. What comprehension strategy would best help her students to realize they may not understand the content as they read? (a) **self-monitoring and fix-up strategies** (b) making mental pictures of the text (c) activating their background knowledge (d) answering questions at the end of the chapter	Pedagogical content knowledge
23. You observe your student teacher asking students to think about things that happened to them that are similar to what happened to the character in the story. This is an example of: (a) predicting (b) summarizing (c) **activating prior knowledge** (d) building background knowledge	Pedagogical content knowledge
24. After you read a story to your students, you ask your students to recall important details from the story. This is an example of: (a) **highlighting** (b) monitoring (c) generating questions (d) inferencing	Pedagogical content knowledge
25. You plan to read a story to your students about a rainbow. You want to be sure that your students will understand the story so you first provide them with a brief explanation of how a rainbow forms before you read the story. This is an example of: (a) building story structure	Pedagogical content knowledge

(b) predicting (c) **building background knowledge** (d) making connections	
26. One example of an activity that teachers can use to assist with multi-strategy instruction is: (a) explicit instruction (b) **reciprocal teaching** (c) sustained silent reading (d) journal writing	Pedagogical content knowledge
27. As you read a passage from a book about ants, you are telling the students what you are doing and why, as you do it. This is an example of: (a) monitoring comprehension (b) **using a think aloud strategy** (c) inferencing (d) highlighting	Pedagogical content knowledge
28. Kyle, one of Mrs. Valcourt's first-grade students, reads the sentence, "The hot dog tasted great!" However, Greg pronounced the word *great* as *greet*. What should Mrs. Valcourt say? (a) Tell me the sound of each letter, then tell me the whole word. (b) Think, what do the first part and the last part of the word say? Now put them together. (c) Think what sound the *ea* spelling pattern makes. Now say the whole word. (d) **This word doesn't follow the rules. This is the word 'great.'**	Pedagogical content knowledge
29. Mrs. Frank is teaching her students to identify multi-syllable words. Which is an appropriate first step for her to do? (a) **model analyzing words for familiar prefixes and suffixes** (b) show students how to blend individual letter-sounds, left-to-right (c) model how to look for little words in big words (d) demonstrate sequentially blending onsets and rimes	Pedagogical content knowledge
30. Circle the word that is a real word when you sound it out: (a) churbit	Content knowledge

(b) wolide **(c) candadett** (d) rigfap	
31. Circle the word that is a real word when you sound it out: **(a) vareaunt** (b) reatloid (c) lofam (d) foutray	Content knowledge
32. Circle the word that is a real word when you sound it out: (a) napsate (b) pagbo (c) plizzle **(d) beekahz**	Content knowledge
33. Circle the word that is a real word when you sound it out: (a) zipanewnew (b) agritolnal **(c) bewtiphul** (d) isengraneal	Content knowledge

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