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Teacher Knowledge About Reading Fluency and Indicators of Students' Fluency Growth in Reading First Schools

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This study examines the role of teacher knowledge about reading fluency in students' fluency growth. Specifically, the effects of teacher knowledge on fluency with nonsense word reading and oral passage reading were examined. Students' vocabulary was also considered as a predictor of fluency development. Results demonstrated that teacher knowledge about reading fluency is a significant predictor of first-grade students' decoding growth and second-grade students' oral reading fluency growth. Effects on third-grade students' reading

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growth are less pronounced. Implications for future research and professional development practice are discussed.

Reading fluency is a critical component of reading proficiency. Since the publication of the National Reading Panel (NRP) report (National Reading Panel, 2000), reading fluency has garnered much attention in the professional literature. Although many definitions of reading fluency exist, it can be broadly defined as the ability to read with accuracy, automaticity, and prosody (Hudson, Lane, & Pullen, 2005). According to Wolf and Katzir-Cohen's (2001) more comprehensive definition, reading fluency is "a level of accuracy and rate where decoding is relatively effortless, where oral reading is smooth and accurate with correct prosody, and where attention can be allocated to comprehension" (p. 219). Even more broadly, in addition to defining fluency as "the ability to read quickly, accurately, and with proper expression" (p. 3–5), the NRP states "the fluent reader is one who can perform multiple tasks—such as word recognition and comprehension—at the same time" (p. 3–8). Ultimately, the purpose of achieving a fluent level of reading is to free cognitive resources to be devoted to understanding text, or as Harris and Hodges (1995) explain, fluency achieves "freedom from word identification problems that might hinder comprehension" (p. 85).

Fluency is considered one of the essential elements of reading, due mainly to its influence on comprehension (Fuchs, Fuchs, Hosp, & Jenkins, 2001; Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003). Fluency is, indeed, an important contributor to comprehension, especially in the primary grades (Schatschneider et al., 2004), but it is also cited as important for motivation (Good, Simmons, & Kame'enui, 2001; Smith, Simmons, & Kame'enui, 1998), syntactic development (Chomsky, 1972), and vocabulary development (Nathan & Stanovich, 1991). Fluent readers are exposed to more text in the same amount of time, and exposure to text promotes both fluency and comprehension (Spear-Swerling, 2006). Thus, the consequences of disfluent reading go beyond the inherent breakdown in comprehension. Disfluent reading may lead to problems with other aspects of language and literacy. The disfluent reader is also more likely to be unmotivated to engage in reading and, therefore, has less exposure to text and fewer opportunities to practice, which can lead to the ever-widening gap between good readers and poor readers that Stanovich refers to as the Matthew Effect (Stanovich, 1986).

Research on reading fluency has yielded numerous recommendations of instructional practices to promote fluency during early reading instruction. These recommended practices include developing word recognition to the point of automaticity (Ehri, 2005); teacher modeling of fluent oral reading (Blevins, 2001; Rasinski, 2003); providing recorded fluent models (Carbo, 1992; Dowhower, 1987; Hasbrouk, Ihnot, & Rogers, 1999); repeated readings of connected text (Rasinski, 2003; Samuels, 1979); timed readings (Mercer,

Campbell, Miller, Mercer, & Lane, 2000); encouraging extensive independent reading of text at an appropriate level (Allington, 2000); and cueing phrase boundaries to promote prosody (Rasinski, 2003).

Just as there are many ways to develop students' reading fluency, numerous methods for assessing reading fluency have been developed. Although the most common method of assessment is timing oral reading rate and accuracy, there are other means of measuring one or more elements of fluency. For example, accuracy may be assessed using a running record and miscue analysis (Clay, 1984, 1993), and prosody may be assessed through attention to phrasing, smoothness, and pace (Pinnell et al., 1995; Zutell & Rasinski, 1991).

The NRP (2000) lamented that "despite its importance as a component of skilled reading, fluency is often neglected in the classroom" (p. 11). In studies of teaching practices (Allington & Johnston, 2000; Pressley et al., 2001), exemplary teachers have been observed implementing many of the practices recommended to enhance fluency. In these same studies, more typical teachers did not implement the recommended practices consistently. The problem is a challenging one, because the reasons for limited implementation of instructional practices to promote reading fluency are unclear. Teachers' understanding of the construct of fluency, including its components and its importance, and their knowledge of effective pedagogy, including research-based methods for assessment and instruction, may play a role.

A study of reading courses in teacher education programs indicated that they seldom include any emphasis on the development of reading fluency (Walsh, Glaser, & Wilcox, 2006), so new teachers are unlikely to begin their careers with the knowledge and skills necessary to promote fluent reading. Teachers commonly rely on basal reading programs for guidance in designing and implementing reading instruction (Barr & Sadow, 1989; Blok, Otter, Overmaat, de Glopper, & Hoeksma, 2003; Pressley et al., 2001). Basal reading programs have traditionally focused on word recognition, vocabulary, and comprehension (Allington, 1983; Stein, Johnson, & Gutlohn, 1999), and until recently, most programs have not included a component to address fluency instruction (Osborn, Lehr, & Hiebert, 2003). Because fluency is emphasized neither in programs designed to prepare teachers to teach reading nor in basal reading programs, many teachers may have limited knowledge about fluency.

Studies of teacher knowledge about reading have consistently demonstrated gaps in knowledge about reading that have potentially serious implications for practice (Brady & Moats, 1997; Mather, Bos, & Babur, 2001; McCutchen, Harry, Cunningham, Cox, Sidman, & Covill, 2002; Moats, 1994; O'Connor, 1999; Spear-Swerling & Brucker, 2004; Troyer & Yopp, 1990). Studies that have examined the role of professional development in increasing teacher knowledge or improving practice have had mixed results (Bos, Mather, Narr, & Babur, 1999; Cochran-Smith & Lytle, 1999; Cunningham, Perry, Stanovich, & Stanovich, 2004; Hiebert, Gallimore, & Stigler, 2002;

McCutchen, Abbott, Green, Beretvas, Cox, Potter, Quiroga, & Gray, 2002; McCutchen, Harry, Cunningham, Cox, Sidman, & Coyill, 2002; Moats & Foorman, 2003; O'Connor, 1999). Bridging the gap from research-based knowledge to instructional practice is one of the greatest challenges in the field of education (Carnine, 1997, 1999; Gersten & Dimino, 2001; Hiebert et al., 2002).

Reading First is the largest and most comprehensive effort in our nation's history to bridge the research-to-practice gap in literacy education. Reading First is a nationwide federal initiative, established under the No Child Left Behind Act (NCLB, 2001), and "dedicated to help states and local school districts eliminate the reading deficit by establishing high-quality, comprehensive reading instruction in kindergarten through grade 3" (U.S. Department of Education, 2006). Reading First is intended to improve instructional practice in reading achievement in low-performing schools. A primary focus of Reading First has been teacher professional development that emphasizes the implementation of research-based practices in reading instruction. Much of this professional development has revolved around the findings of the National Reading Panel related to phonemic awareness, phonics, fluency, vocabulary, and comprehension.

Florida was one of the first states to receive Reading First funding and to implement the initiative statewide. The Florida Department of Education has been awarded $300 million over six years to implement Reading First across the state. In Florida, 587 elementary schools participate in Reading First. In these schools, more than 14,000 educators serving more than 350,000 students have taken part in Reading First professional development activities. These activities have included statewide Reading Academies and Leadership Conferences, as well as district-based professional development activities and school-based coaching. All teachers in Reading First schools in Florida participate in the Reading Academies, and each Reading First school has a reading coach to provide and facilitate ongoing, site-based professional development. Regional coordinators provide ongoing professional development and support to the school-based reading coaches. Reading First teachers in Florida have received professional development related to reading fluency through the Reading Academies and from their reading coaches, and coaches have received professional development related to reading fluency from their regional coordinators.

We were interested in how teachers and students in Reading First schools were doing in the area of reading fluency. Specifically, given the focus of Reading First on professional development, we were interested in what teachers knew about reading fluency, one of the five key areas of reading emphasized in Reading First. We were also interested in the reading fluency development of their students. Finally, and most importantly, we were interested in the relationship between teachers' knowledge of reading fluency and their students' growth in rate and accuracy.

METHOD

Student and teacher data were collected in 11 schools in nine Reading First school districts in Florida. The nine districts were selected to represent the broad spectrum of population demographics in Florida. Three were large, urban districts; three were medium-sized districts; and three were small, rural districts. The selected districts were also distributed throughout various geographic regions of the state. (Table 1 contains a summary of participating schools.) Schools were selected to represent the population of students in Reading First schools in each district.

PARTICIPANTS

Teachers

All teachers in kindergarten through third grade at the selected schools were invited to participate in the study. Of 146 teachers, a total of 133 teachers completed the survey. Of these, student reading data were available for 117. The remaining teachers were in support roles (e.g., special education, Title I, reading coach) and therefore did not have classroom assignments. The sample included 27 kindergarten teachers, 29 first-grade teachers, 20 second-grade teachers, and 24 third-grade teachers. The majority of teachers in the sample was female (95%), Caucasian (73%), and held a bachelor's degree (75%). The range of teaching experience was 0 to 36 years, with an average of 11.88. Table 2 summarizes teachers' demographic information.

TABLE 1 Summary Data for Participating Schools

School	Number of teachers participating	District size	Region	Percent of students receiving free or reduced-price lunch
1	4	Medium	Central	58
2	8	Small	North	81
3	7	Large	South	61
4	11	Medium	Central	50
5	12	Small	Central	56
6	11	Large	South	97
7	18	Small	North	72
8	10	Large	North	87
9	6	Large	South	92
10	16	Large	South	60
11	14	Medium	Central	66

TABLE 2 Summary of Teacher Demographic Data

Gender	Race	Highest level of education	Years of teaching experience
111 female	85 Caucasian	88 held a bachelor's degree	37 had 0–4 years
6 male	22 African-American	27 held a master's degree	20 had 5–9 years
	6 Latino	2 held a specialist degree	27 had 10–19 years
	4 Other		25 had 20–29 years
			7 had 30 or more years

Note. Some teachers did not provide all demographic data.

Students

All students who were enrolled in each of the participating teachers' classrooms across the state of Florida were participants in this study (N = 1,717 students in first through third grades). Of these students, 816 were in schools in large, urban districts; 353 were in schools in medium-sized districts; and 548 attended schools in small, rural districts.

The sample had 880 boys and 835 girls in grades 1 (n = 694), 2 (n = 532), and 3 (n = 491), with two students who are unidentified as to gender. Using information from school records, 36% of the children were identified as Caucasian, 38% as African American, 1% as Asian/Pacific Islanders, 20% as Hispanic, 3% as Multiracial, and .3% as American Indian, with 2% of the sample unreported. Using socioeconomic status information provided by school personnel, 71% of the participants were eligible for free or reduced-price lunch (66 students unidentified). According to school records, 85% had no identified disability label, .2% had a primary disability identification of mild mental retardation, 7% had a speech/language impairment, 1% was emotionally handicapped, and 6% had a specific learning disability; 3% were identified as gifted. Many of the students were served in programs for speakers of English as another language. Twelve percent were currently enrolled, 4% had been in enrolled and were exited within the last two years, and 1% had been in enrolled and were exited more than two years ago.

MEASURES AND PROCEDURES

Teacher Measure

We were interesting in examining teachers' knowledge about the construct of reading fluency, their understanding of why it was an important element of reading development, and their pedagogical knowledge related to assessment and instructional practice. Participating teachers completed a survey of knowledge about reading fluency. The survey was developed and refined

through a series of pilot administrations. The survey comprised the following open-ended questions:

- What is reading fluency?
- Why is it important for children to develop reading fluency?
- What knowledge and skills do children need to become fluent readers?
- How can reading fluency be assessed?
- What instructional methods could be used to develop reading fluency?

These questions allowed for a broad examination of teachers' understanding about the important aspects of fluency. The questions were intentionally broad to capture as much as possible of what teachers knew on the topic and were not tied to any specific professional development objectives. Questions were open-ended to allow teachers to demonstrate their knowledge without prompts that would be provided with other types of questions. The survey also included a request for demographic information, including gender, race, highest level of education, and years of teaching experience (see Table 2).

Surveys were group-administered by Reading First regional coordinators at the school sites. All teachers of kindergarten through third grade at participating schools were invited to participate in the study. Teachers who elected to participate individually completed the survey that day in the group setting. Teachers were not provided time to prepare or study for the assessment and, during survey administration, teachers were not permitted to discuss their responses with others or use any resources to develop their answers. Completion of the survey took between 20 and 50 minutes.

Teachers' responses were scored using a rubric (see Appendix A) to assign a point value to the response for each question. Each survey was scored by two of the researchers, and scores were compared. Initial interscorer agreement was 94%. All surveys in which there were disagreements for scores on particular items were scored by a third researcher, and a final score was assigned for each item. In addition to the survey questions previously listed, teachers were also asked to identify the methods they employed in their classroom. Sample responses at each level of the rubric are presented in Appendix B. These responses were recorded and tabulated (see Table 3). The most common methods teachers identified were modeling fluent reading, repeated readings, practicing with peers, timed reading, choral reading, and readers' theatre.

Student Measures

We were also interested in student reading fluency development and how it related to teacher knowledge and other aspects of reading growth. Students in Reading First schools in Florida are administered several measures of

TABLE 3 Methods Used for Promoting Fluency as Reported by Teachers

Method	Number of teachers who named method
Modeling fluent reading	46
Repeated readings	44
Practice with peers	33
Timed readings	26
Choral reading	23
Readers' theatre	20
Books on tape	16
Decoding practice	15
Poems, chants	14
Echo reading	13
Phrasing practice	12
Independent reading	6
Sight word practice	5
Computer-assisted methods	4

reading each year. All student assessment data are entered into the state's Performance Monitoring Reporting Network (PMRN) database, and we retrieved student data for this study from the PMRN.

We used two subtests of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS, Kaminski & Good, 1996). The Nonsense Word Fluency (NWF) subtest provides an indicator of the development of efficiency in decoding skills. Students are presented with vowel-consonant and consonant-vowel-consonant nonsense words to decode in a one-minute timed format. The Oral Reading Fluency (ORF) subtest provides an indicator of students' accuracy and rate while reading connected text. The ORF is also administered in a one-minute timed format. These measures were conducted at four time points evenly spread across the school year from the beginning to the end, which allows for an examination of growth.

The Peabody Picture Vocabulary Test (PPVT, Dunn & Dunn, 1999) was also used as a student measure. The PPVT provides an indicator of students' receptive vocabulary and is generally considered to provide a reasonable gauge of students' verbal abilities. The PPVT was administered at the end of the school year in participating schools.

RESULTS AND DISCUSSION

Data Analysis

The data were analyzed using latent growth models (LGM) (Hancock & Lawrence, 2006; McArdle & Epstein, 1987) and multilevel latent growth models (MLGM) (Duncan et al., 1997). All models were fit to the data using MPLUS 4.2 (Muthén & Muthén, 2006). In the first part of the

analysis, unconditional LGM (i.e., latent growth models without predictors) were used to determine the shape of growth of decoding fluency as measured by Nonsense Word Fluency (NWF) and reading fluency as measured by Oral Reading Fluency (ORF) across four measurement occasions during one academic year. From the three samples of students obtained (first-, second-, and third-graders), NWF was measured in the first- and second-grade samples, while ORF was measured in all three grades. Kindergarten students were not assessed on any one measure across the entire school year to allow examination of student growth, so only teacher knowledge data are reported for the purpose of comparison across grade levels.

The first analysis evaluated the shape of the students' growth using an unconditional LGM. This is an important preparatory step to MLGM because it is easier to identify misspecified growth shapes in simpler models. With the LGM, student data were analyzed while ignoring the teacher variable because only the shape of growth was of interest, and it was assumed not to vary between students who were taught by different teachers. In this study, one latent growth model was fit for each combination of grade and outcome variable (decoding fluency and reading fluency). The linear growth model fit to the data is displayed in Figure 1. The LGM is similar to a confirmatory factor analysis model, but the indicators are the outcome variables measured at different time points. The factor loadings are fixed to values that correspond to the hypothesized growth shape. In this study, the factor loadings were fixed at −3, −2, −1, and 0, which correspond to a hypothesized linear growth shape for the NWF and ORF. Because the factor loading of the last measurement occasion was fixed at 0, the intercept is interpreted as the status of NWF

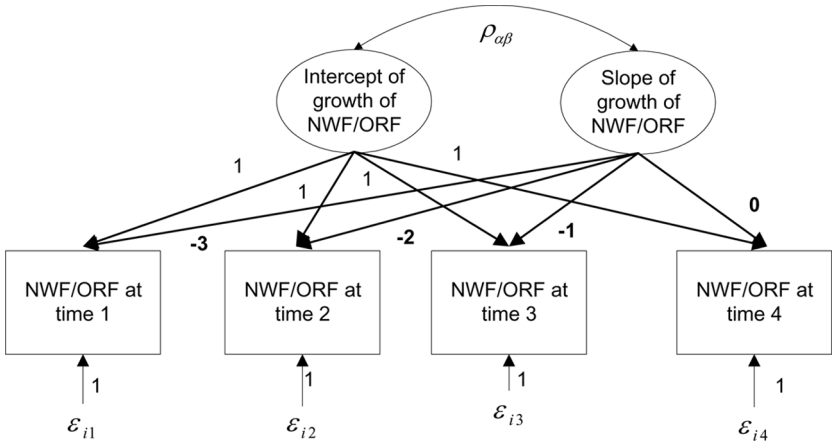

FIGURE 1 Linear latent growth model of decoding and oral reading fluency with no predictors. Abbreviations: NWF = Nonsense Word Fluency subtest of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS); ORF = Oral Reading Fluency subtest of DIBELS.

and ORF at the end of the academic year. Defining the intercept at the last measurement time facilitates the interpretation of the effect of teacher-level variables on the intercept. The appropriateness of the hypothesized growth shape was evaluated using the chi-square statistic and fit indices (i.e., CFI, TLI, and RMSEA).

After a well-fitting growth shape was identified for both decoding fluency and reading fluency using LGM, multilevel latent growth models were used to identify the effects of different aspects of teacher reading fluency knowledge (i.e., definition, importance, skills, assessment, and instruction) on the intercept of the students' growth on each of decoding fluency and reading fluency while controlling for the students' vocabulary as measured by the PPVT.

MLGMs are a combination of multilevel structural equation models (Muthén, 1994) with latent growth models. They decompose the total variance/covariance matrix of decoding fluency and reading fluency into a within-teacher variance/covariance matrix and a between-teacher variance/covariance riance matrix, and fit a latent growth model to each matrix. The MLGMs used are equivalent to three-level hierarchical linear models (Raudenbush & Bryk, 2002), where the first level outcomes are the students' decoding fluency and reading fluency scores measured at multiple time points, the second level outcomes are the students' intercepts and slopes, and the third level outcomes are the teachers' intercepts (Duncan et al., 1997). Vocabulary was included in the model as a covariate to account for the within-teacher variance/covariance matrix, which is due to differences between students.

The main focus of this study is on teacher reading fluency knowledge variables, which were included to account for the between-teacher variance/covariance matrix, which we hypothesize to be, at least in part, due to differences in knowledge about reading fluency. We used each of the questions on the teacher knowledge measure as a separate independent variable because both theory and the low inter-item correlations suggested that they measured separate constructs. The only significant correlations were between questions 1 and 3 ($r = .23$), questions 1 and 4 ($r = .28$), and questions 2 and 3 ($r = .43$). Thus, we included knowledge of each element:

- Q1: the definition of reading fluency,
- Q2: why reading fluency is important,
- Q3: what skills are needed for reading fluency,
- Q4: how to assess reading fluency, and
- Q5: ways to provide instruction in reading fluency.

The MLGM models used are shown in Figure 2.

The data set used in this study contained missing values in both dependent and independent variables for student-level variables. The missing values in the dependent variables were addressed using full information

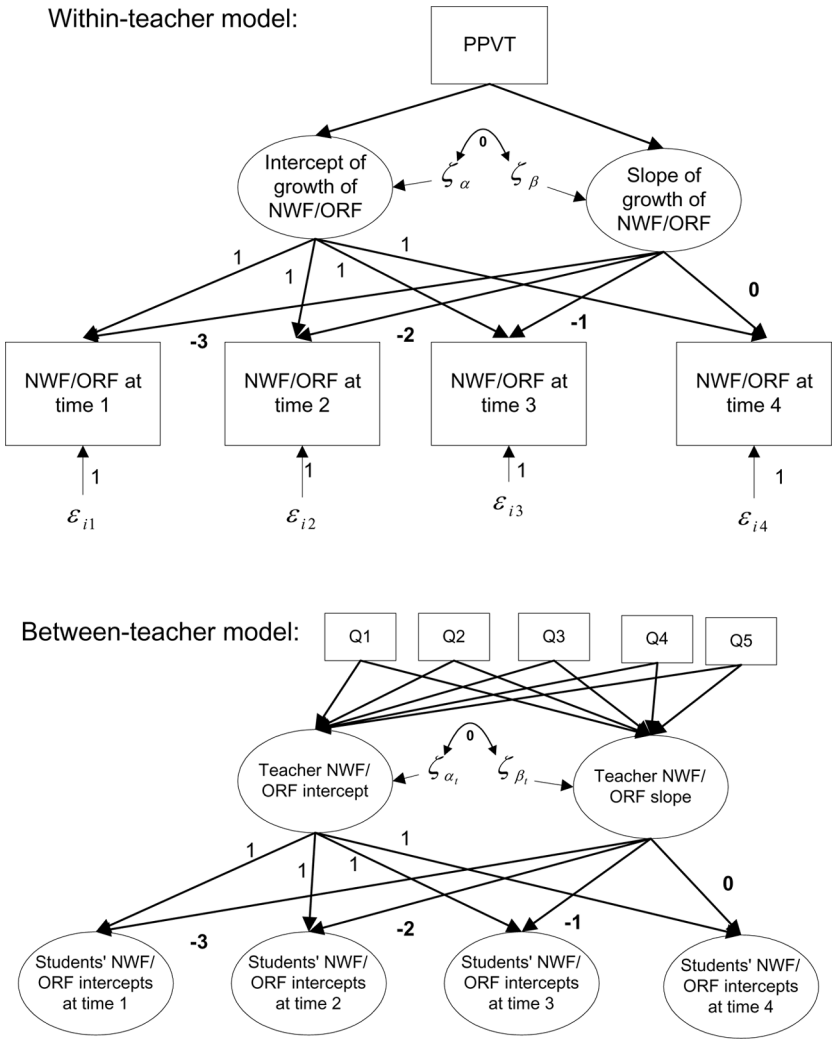

FIGURE 2 Multilevel latent growth models of within-teacher and between-teacher effects on decoding and oral reading fluency. *Note.* The correlations between latent residuals ζ_α and ζ_β were fixed at zero to increase the number of degrees of freedom. Abbreviations: Q1 = definition of reading fluency; Q2 = why reading fluency is important, Q3 = what skills are needed for reading fluency; Q4 = how to assess reading fluency, and Q5 = instructional methods for reading fluency. PPVT = *Peabody Picture Vocabulary Test;* NWF = Nonsense Word Fluency subtest of the *Dynamic Indicators of Basic Early Literacy Skills* (DIBELS); ORF = Oral Reading Fluency subtest of DIBELS.

maximum likelihood (FIML) (Enders, 2001) for model estimation, which uses all the available data for each student. However, FIML cannot be used with missing data in the independent variables, and cases with missing data on independent variables were excluded from the analyses. The percentage of

cases with missing dependent variable values in first and second grade on decoding fluency ranged from 18−20% and 15−20%, respectively. On reading fluency, the missing values ranged from 18−20% (first grade), 14−19% (second grade), and 15−23% (third grade). For the vocabulary measure, 7% of cases in first and second grade were missing values and 9.6% were missing in third grade. There were no missing data for the teacher data.

Descriptive Statistics

Teachers' knowledge survey scores varied substantially across teachers, grade levels, and survey questions. Means and standard deviations for teachers by grade level and question are presented in Table 4. In general, third-grade teachers were the most knowledgeable about fluency, followed by second-grade teachers, and so on. Figure 3 illustrates this pattern. The correlation matrix for the teacher survey questions is presented in Table 5. The descriptive statistics for the students' decoding and reading fluency can be found in Table 6.

Growth Models

Latent growth models were used to test the hypothesis that the growth of the NWF and ORF was linear. The chi-square statistics and fit indices for these linear growth models are shown in Table 7. The values of the chi-square statistic and the RMSEA indicate that the linear models do not fit the data well, while the CFI and TLI indicate that the fit is adequate. However, Leite & Stapleton (2006) has found that the chi-square statistic and RMSEA are very sensitive to slight departures of linearity of growth, while the TLI and CFI are sensitive to moderate and strong nonlinearity of growth shape, respectively. Therefore, we decided to retain the linear model based on the values of the CFI and TLI.

The unconditional LGM produced estimates of the means and variances of intercept and slope, and the correlation between intercept and slope, but these are fixed-effect estimates that ignore the nesting of students within

TABLE 4 Means and Standard Deviations for Teacher Scores on Survey Questions

Teacher grade level	Q1 *M* (*SD*)	Q2 *M* (*SD*)	Q3 *M* (*SD*)	Q4 *M* (*SD*)	Q5 *M* (*SD*)
Kindergarten	1.47 (.74)	0.97 (.55)	1.47 (.76)	1.45 (.69)	1.36 (.81)
First	1.74 (.59)	1.13 (.56)	1.37 (.66)	1.48 (.75)	1.56 (1.21)
Second	1.90 (.55)	1.25 (.70)	1.55 (.60)	1.73 (.57)	1.80 (.71)
Third	1.99 (.76)	1.36 (.76)	1.84 (.70)	1.60 (.58)	1.94 (.94)

Abbreviations: Q1 = definition, Q2 = importance, Q3 = skills needed, Q4 = assessment, Q5 = instruction.

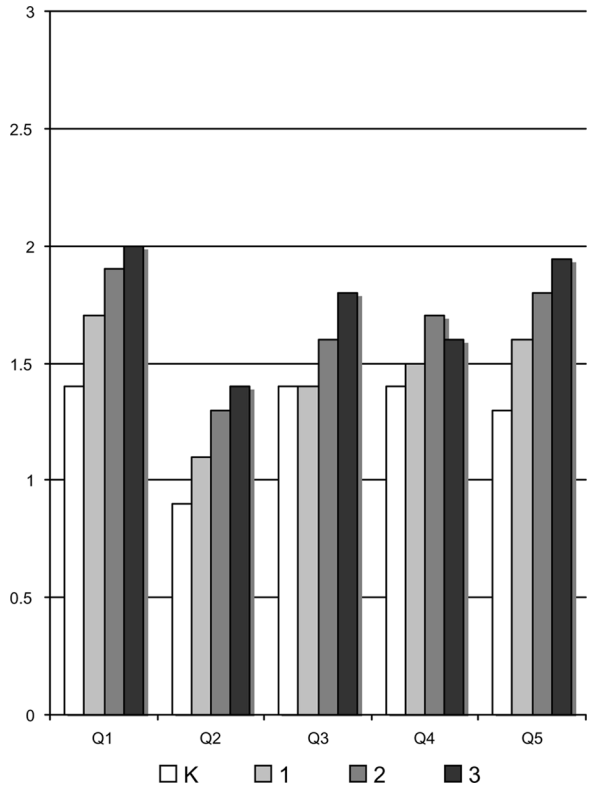

FIGURE 3 Mean teacher knowledge scores by grade level for each question. Abbreviations: Q1 = definition, Q2 = importance, Q3 = skills needed, Q4 = assessment, Q5 = instruction.

teachers. Because this study focuses on the differences in student growth between teachers, the fixed-effect estimates obtained with the unconditional LGM are not reported.

The next step was to fit the multilevel latent growth model with vocabulary as the student-level predictor and fluency knowledge variables as teacher-level predictors. The data were centered at time 4, which makes

TABLE 5 Correlation Matrix of Teacher Survey Questions

	Q1	Q2	Q3	Q4	Q5
Q1	1				
Q2	.235*	1			
Q3	.265*	.484*	1		
Q4	.323*	.133	.160	1	
Q5	.082	.254*	.236*	.059	1

*$p < .01$.
Abbreviations: Q1 = definition, Q2 = importance, Q3 = skills needed, Q4 = assessment, Q5 = instruction.

TABLE 6 Descriptive Statistics of Student Reading Achievement

	Time 1 NWF *M* (*SD*)	Time 1 ORF *M* (*SD*)	Time 2 NWF *M* (*SD*)	Time 2 ORF *M* (*SD*)	Time 3 NWF *M* (*SD*)	Time 3 ORF *M* (*SD*)	Time 4 NWF *M* (*SD*)	Time 4 ORF *M* (*SD*)	PPVT *M* (*SD*)
First grade	27.62 (18.51) $n = 492$	12.13 (14.14) $n = 492$	44.08 (20.45) $n = 527$	21.05 (19.73) $n = 527$	49.34 (24.35) $n = 540$	34.29 (24.35) $n = 540$	49.31 (24.39) $n = 534$	34.21 (24.64) $n = 534$	91.51 SS (15.74) $n = 626$
Second grade	59.23 (32.93) $n = 413$	54.15 (32.43) $n = 413$	72.73 (37.99) $n = 425$	66.29 (31.17) $n = 425$	78.05 (40.24) $n = 440$	76.89 (35.04) $n = 440$	78.84 (40.23) $n = 433$	77.60 (35.07) $n = 433$	93.56 SS (14.57) $n = 511$
Third grade	–	74.37 (28.92) $n = 377$	–	84.24 (31.22) $n = 389$	–	96.14 (31.18) $n = 398$	–	96.66 (30.64) $n = 403$	95.00 SS (14.35) $n = 471$

Abbreviations: n = number of cases with no missing data at each time point; NWF = Nonsense Word Fluency subtest of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS), correct sounds per minute; ORF = Oral Reading Fluency subtest of DIBELS, correct words per minute; PPVT = Peabody Picture Vocabulary Test.

TABLE 7 Fit Indices for Unconditional Linear Growth Models

Outcome	Fit statistic/index	Linear model
First grade		
Decoding fluency	Chi-square	59.569 ($p < 0.05$)
	CFI	0.951
	TLI	0.941
	RMSEA	0.157
Reading fluency	Chi-square	62.952 ($p < 0.05$)
	CFI	0.973
	TLI	0.968
	RMSEA	0.162
Second grade		
Decoding fluency	Chi-square	46.960 ($p < 0.05$)
	CFI	0.966
	TLI	0.959
	RMSEA	0.153
Reading fluency	Chi-square	16.613 ($p < 0.05$)
	CFI	0.995
	TLI	0.994
	RMSEA	0.081
Third grade		
Reading fluency	Chi-square	43.313 ($p < 0.05$)
	CFI	0.978
	TLI	0.973
	RMSEA	0.155

Criteria for model rejection: $p < 0.05$, CFI/TLI < 0.95, RMSEA > 0.06, SRMR > 0.08 (Hu & Bentler, 1999).

the intercept the mean student score on decoding fluency and reading fluency at the end of the year. The slope is the amount of growth in decoding or reading fluency expected to occur for each unit of the factor loadings that define the growth trajectory. For the linear model, the units of the factor loadings correspond to the units of time between measurements, which implies that the slope is the expected amount of growth between measurements.

Vocabulary

Vocabulary was found to predict the intercept of both decoding and reading rate and accuracy in first and second grade (see Table 8 for the regression coefficients). It was also found to predict the slope of reading fluency in first grade. Students with higher vocabulary scores had higher final decoding and reading fluency scores, and first-grade students with higher vocabulary scores grew more in their reading fluency over the year. This finding supports the contention by Hudson, Pullen, Lane, and Torgesen (2009) in this issue and Wolf and Katzir-Cohen (2001), that vocabulary is essential to rapid retrieval. That vocabulary was most relevant for first graders is not surprising. As children are learning to decode, they

TABLE 8 Coefficients of the Regression of the Intercept and Slope of Decoding and Reading Fluency on Vocabulary

	NWF intercept			NWF growth slope			ORF intercept			ORF growth slope		
	Coef.	*p*	Std.	Coef.	*p*	Std.	Coef.	*p*	Std.	Coef.	*p*	Std.
1st grade	.14	.00	.21*	− .00	.79	.02	.28	.00	.34*	.05	.00	.29*
2nd grade	.40	.00	.35*	.01	.67	.05	.53	.00	.51*	.01	.40	.13
3rd grade							.36	.00	.37*	.01	.59	.10

*indicates statistically significant coefficients.
Abbreviations: Coef. = unstandardized regression coefficient, Std. = standardized regression coefficient.

rely on the words they understand to help them decipher the unfamiliar words and they confirm or refute their attempts at decoding by asking themselves if a word makes sense in the context. Children with larger vocabularies have more known words to rely on. However, the relationship between vocabulary and fluency is very likely reciprocal. That is, not only does a strong vocabulary help fluency improve, fluent reading exposes children to more words, thereby increasing their vocabularies through repeated exposure to words (Beck, Perfetti, & McKeown, 1982).

Teacher Knowledge

Overall, the teacher knowledge variables explained 25% of the variance in the growth of decoding fluency and 11% of the growth of reading fluency in their first-grade students. In the second grade, teacher knowledge explained 59% of the growth in decoding fluency and 86% of reading fluency. In contrast, the teacher knowledge variables explained no variance in the reading fluency of the third graders in our sample (R^2 of .03). This finding reflects developmental patterns of fluency growth. That is, the period of greatest growth in decoding is first grade (Compton, 2000), and the most growth in reading fluency occurs during second grade (Hasbrouck & Tindal, 2006). Teachers who are knowledgeable about these constructs may be more likely to provide appropriate instruction to stimulate growth.

Relationships Between Single Predictors and Decoding and Reading Fluency

We first examined the bivariate relationships between each of the teacher knowledge questions and decoding fluency. The resulting regression coefficients are presented in Table 9. The coefficients represent the predicted change in decoding fluency that is associated with a one standard deviation change in each teacher knowledge variable.

TABLE 9 Effects of Individual Teacher Reading Fluency Knowledge Elements on Intercept and Slope of Growth of Decoding and Reading Fluency

	NWF intercept			NWF growth slope		
	Coef.	*p*	Std.	Coef.	*p*	Std.
First grade						
Q1: Definition	−4.20	0.234	−0.231	−1.15	0.212	−0.341
Q2: Importance	8.25	0.026	0.383*	1.95	0.030	0.511*
Q3: Skills needed	9.25	0.004	0.542*	1.70	0.030	0.564*
Q4: Assessment	−1.80	0.568	−0.125	−0.70	0.368	−0.279
Q5: Instruction	5.50	0.004	0.628*	0.60	0.180	0.412
Second grade						
Q1: Definition	−5.60	0.362	−0.202	−2.85	0.116	−0.486
Q2: Importance	0.95	0.818	0.030	−0.70	0.478	−0.143
Q3: Skills needed	6.10	0.208	0.231	2.05	0.098	0.384
Q4: Assessment	5.40	0.358	0.196	2.10	0.080	0.380*
Q5: Instruction	2.50	0.59	0.105	1.60	0.162	0.331
	ORF intercept			ORF growth slope		
	Coef.	*p*	Std.	Coef.	*p*	Std.
First grade						
Q1: Definition	−1.95	0.638	−0.119	−0.10	0.904	−0.031
Q2: Importance	1.50	0.576	0.078	0.70	0.204	0.190
Q3: Skills needed	5.20	0.100	0.345	0.60	0.396	0.211
Q4: Assessment	−3.00	0.268	−0.231	−0.50	0.396	−0.206
Q5: Instruction	3.05	0.116	0.387	0.70	0.058	0.471
Second grade						
Q1: Definition	−0.35	0.952	−0.017	−0.10	0.920	−0.034
Q2: Importance	2.40	0.590	0.129	1.25	0.046	0.554*
Q3: Skills needed	4.15	0.254	0.212	0.60	0.358	0.251
Q4: Assessment	2.35	0.652	0.117	1.90	< .001	0.805*
Q5: Instruction	−1.70	0.690	−0.097	1.65	< .001	0.838*
Third grade						
Q1: Definition	4.65	0.272	0.207	0.80	0.304	0.299
Q2: Importance	5.30	0.162	0.272	0.15	0.826	0.063
Q3: Skills needed	8.85	0.034	0.434*	0.70	0.226	0.270
Q4: Assessment	6.20	0.332	0.228	0.35	0.674	0.108
Q5: Instruction	7.35	0.038	0.459*	0.25	0.704	0.120

*$p < .05$.

Abbreviations: Coef. = unstandardized regression coefficient, Std. = standardized regression coefficient.

In the first grade, students whose teachers knew more about the importance of reading fluency, necessary skills for fluent reading, and instructional methods to teach reading fluency finished the year with higher decoding fluency than did students whose teachers knew less. For every standard deviation increase in teacher knowledge, students finished the year 8.25, 9.25, and 5.5 words higher than their peers, respectively. Teachers who knew more about the importance of reading fluency and needed skills also had students who grew more in decoding fluency throughout the year, 5.85 and 5.1

words a year per standard deviation. With standardized coefficients ranging from .38 to .63, the effects of these elements of teacher knowledge are fairly strong. In the second grade, there were no significant effects of teacher knowledge on decoding fluency.

In the first grade, the effect of teacher knowledge of instructional methods on the reading rate and accuracy of their students approached significance (.058). In the second grade, three areas of teacher knowledge resulted in significant, positive coefficients. The students of teachers who knew more about the importance of reading fluency and methods of assessment and instruction grew more on average than did students of teachers who knew less (3.75, 5.7, and 4.95 words per year respectively). The effect sizes for knowledge of assessment and instructional methods in second grade are quite high (.81 and .84). In the third grade, greater teacher knowledge in the skills needed for fluent reading (8.85 words) and instructional methods to teach it (7.35 words) led to higher reading fluency scores at the end of the year. The effects of teacher knowledge were moderate (.43 and .46).

Again, the relationship between the effects of teacher knowledge and typical developmental patterns for the growth of decoding and reading fluency is predictable. Teachers who know more about the skills needed for fluent reading (i.e., skills such as decoding accuracy and automaticity with word reading) have students with greater decoding growth in first grade, when most decoding development occurs. Teachers who understand the importance of reading fluency and are knowledgeable about effective practices for reading fluency assessment and instruction are more likely to employ effective methods at the appropriate developmental phase. This is evident in the results for the second grade. As reading fluency growth begins to level off in the third grade, the effects of teacher knowledge become less pronounced.

Model With All Predictors

We also analyzed the effects of teacher knowledge with all the predictors in the model to examine the unique variance contributed by each element of knowledge. With first-grade data, we controlled for differences due to years of teacher experience by including it in the model as a covariate. In the first grade, years of teaching experience was slightly negatively related to students' growth in decoding fluency. This finding may be due to the increased emphasis in recent years on phonics instruction. That is, teachers with fewer years of experience likely received their teacher preparation at a time when decoding instruction was emphasized. The variable years of teacher experience was not included in the analysis of second- and third-grade data because the number of teachers reporting their years of experience was not large enough to allow models including this variable to be identified. In this combined model, no teacher reading fluency knowledge variable

was found to significantly predict the intercept of growth of decoding and reading fluency on all but one of the slopes (see Table 10). In the second grade, the effect of teacher knowledge of skills needed for fluent reading on the decoding fluency of their students approached significance ($p = .051$), and students whose teachers knew more about assessment of reading fluency grew 4.35 more words per standard deviation increase in teacher knowledge per year.

TABLE 10 Effect of All Teacher Reading Fluency Knowledge Variables and Years of Teacher Experience on Intercept and Slope of Growth of Decoding and Reading Fluency

	NWF intercept			NWF growth slope		
	Coef.	*p*	Std.	Coef.	*p*	Std.
First grade						
Q1: Definition	−0.034	0.970	−0.102	−0.017	0.462	−0.279
Q2: Importance	0.083	0.398	0.203	0.027	0.213	0.361
Q3: Skills needed	0.025	0.805	0.079	0.010	0.666	0.166
Q4: Assessment	−0.072	0.093	−0.272	−0.018	0.100	−0.359
Q5: Instruction	0.082	0.209	0.518	0.003	0.841	0.095
Teacher experience	−0.002	0.906	−0.018	−0.010	0.026	−0.414*
Second grade						
Q1: Definition	−0.029	0.768	−0.056	−0.061	0.078	−0.495
Q2: Importance	0.035	0.793	0.074	−0.036	0.206	−0.328
Q3: Skills needed	0.135	0.202	0.271	0.047	0.051	0.404
Q4: Assessment	0.178	0.525	0.343	0.038	0.331	0.311
Q5: Instruction	−0.134	0.608	−0.295	0.014	0.712	0.135
	ORF intercept			ORF growth slope		
	Coef.	*p*	Std.	Coef.	*p*	Std.
First grade						
Q1: Definition	−0.041	0.764	−0.129	0.008	0.761	0.138
Q2: Importance	−0.072	0.347	−0.187	0.012	0.589	0.158
Q3: Skills needed	0.041	0.689	0.139	−0.010	0.680	−0.176
Q4: Assessment	−0.086	0.047	−0.346*	−0.014	0.212	−0.296
Q5: Instruction	0.048	0.473	0.326	0.019	0.150	0.671
Teacher experience	0.048	0.228	0.384	0.001	0.867	0.055
Second grade						
Q1: Definition	0.025	0.810	0.064	−0.009	0.643	−0.182
Q2: Importance	0.109	0.297	0.303	0.018	0.121	0.409
Q3: Skills needed	0.106	0.194	0.280	−0.001	0.895	−0.028
Q4: Assessment	0.223	0.144	0.566	0.029	0.039	0.603*
Q5: Instruction	−0.260	0.063	−0.754	0.008	0.608	0.178
Third grade						
Q1: Definition	−0.001	0.996	−0.001	0.015	0.405	0.281
Q2: Importance	−0.003	0.959	−0.008	−0.002	0.878	−0.044
Q3: Skills needed	0.111	0.281	0.269	0.012	0.379	0.240
Q4: Assessment	0.052	0.701	0.101	−0.003	0.859	−0.051
Q5: Instruction	0.090	0.323	0.287	−0.002	0.902	−0.049

*$p < .05$

Abbreviations: Coef. = unstandardized regression coefficient, Std. = standardized regression coefficient.

In light of the relatively large regression coefficients that explain the unique contributions of each variable, this lack of significance is likely to be a result of a lack of sufficient power to detect effects. Despite the fact we had a fairly large total sample of students, which provides sufficient power to analyze student-level predictors, the number of teachers per grade was not large ($n = 26–32$), which resulted in low power to detect effects of teacher-level variables.

CONCLUSIONS

This study demonstrates that teacher knowledge about reading fluency matters. In general, teachers who knew more had students who read quickly and accurately. There seems to be a developmental pattern at work in that the effects of teacher knowledge are greatest in the areas in which students are expected to demonstrate the greatest growth. First-grade effects were greatest in decoding fluency, at the time when most decoding growth is expected. That is, first-grade students with teachers who knew more about fluency did better on measures of decoding rate and accuracy, the aspect of fluency that is the focus of much instruction in first grade. Second-grade effects were greatest in reading rate and accuracy, when growth was expected. The focus in second grade typically shifts from learning to read words to applying those skills in increasingly extensive reading of connected text. Even though this focus would be expected in all second-grade classrooms, those students with teachers who knew more about fluency demonstrated greater growth in oral reading rate and accuracy. Finally, third-grade effects were smaller at a time when we expect fluency growth to begin to level off. Students' growth in reading rate and accuracy may have been less because more emphasis tends to be placed on comprehension beginning in third grade. Still, the third-grade teachers knew the most about fluency, including its relationship with comprehension. Although it appears that the teachers who knew the most needed the least knowledge, it could be that their understanding of the role of fluency in comprehension contributed to the shift in focus for students.

Overall, in the combined model, knowing what knowledge and skills children needed approached significance, and knowledge of effective assessment practices was significant. In the models that considered each knowledge element separately, it mattered most if teachers knew why reading fluency was important, knew what skills mattered most, and could identify effective instructional methods. Understanding why reading fluency is important demonstrates the capacity to provide appropriate emphasis on fluency development. Teachers who know why they are teaching something may be better able to determine when and for whom to provide instruction. Knowing what skills matter most could help teachers match instruction to

student needs, emphasizing the most important skills. Interestingly, these two questions (i.e., importance and skills needed) were also the most highly correlated. These questions reflect a deeper understanding of fluency, beyond knowing a definition and being able to name effective assessments or instructional methods. Perhaps it is the overall depth of teacher knowledge, rather than knowledge about these specific elements of fluency, that predicts students' reading achievement. Finally, knowledge of effective instructional methods is important in the selection and implementation of those methods. Although we have no evidence regarding which methods teachers actually employed, it seems reasonable to assume that teachers would not implement a method they did not know about.

Although DIBELS has been demonstrated to be a good predictor of performance on state reading tests (Buck & Torgesen, 2003; Carlisle, Schilling, Scott, & Zeng, 2007; Good, Simmons, & Kame'enui, 2001; Shaw & Shaw, 2002), it should be noted that the use of DIBELS and other one-minute assessments as a measure of fluency has been criticized by some researchers. For example, Pressley, Hilden, and Shankland (2006) point out the limitations of DIBELS in predicting performance in comprehension on tests other than state reading tests. Carlisle et al. note that a substantial number of children who are considered "low risk" using DIBELS benchmarks perform below grade level on the ITBS; however, Roehrig, Petscher, Nettles, Hudson, and Torgesen (in press) found that DIBELS was significantly related to performance on the Stanford Achievement Test-10 in third grade. Perhaps the most important concern about DIBELS is that it only measures rate and accuracy, with no concern for prosody, so it is limited as an assessment of fluency. Despite these and other limitations, DIBELS provides a useful indicator of student performance on specific reading-related skills. However, caution should be used in the interpretation of the results.

There were some clear differences in student performance that were related to teacher knowledge, but with the data from this study, we cannot be certain why such differences exist. Teachers with greater knowledge may be employing systematically more effective practices, but without classroom observations, we cannot know this for certain. That teachers can name effective practices does not ensure that they are using these practices. Further study to explore the relationships among teacher knowledge, classroom practice, and student learning is necessary to fully understand these findings. Further research should also examine the content of professional development activities and compare approaches to promoting increased teacher knowledge and effective instructional practice. It is also important to consider other explanations for the relationship. For example, teachers who are motivated to learn more about fluency may also be motivated to put more effort into developing students' fluency. That is, teachers' drive or motivation may be a superseding factor that could explain both greater knowledge and better teaching.

Even without the certain connection to practice, the relationship between teacher knowledge and growth and outcomes in decoding and reading fluency suggest implications for improving professional development. Because traditional professional development practices are insufficient to produce changes in classroom practice, Denton, Vaughn, and Fletcher (2003) recommend that professional development include sustained mentoring to ensure that teachers apply their knowledge in the classroom. Gersten, Chard, and Baker (2000) point out the importance of helping teachers understand the difference between an educational fad and empirically supported practices. They suggest that networks for professional discourse enhance teacher understanding and increase the likelihood that effective practices will be adopted. Reading First provides a framework for such networks, and efforts to connect teachers for such purposes are evident, but it is unclear whether the initiative has capitalized on the network opportunity to its fullest extent.

Despite similar professional development experiences across the state due to teachers' involvement in Reading First (e.g., Reading Academies, site-based coaches), teacher knowledge about reading fluency varied widely. Most teachers had a limited view of reading fluency and did not incorporate all three of the fundamental elements of fluency (accuracy, automaticity, and prosody) in their definitions. Ensuring that all teachers understand fluency and raising awareness of effective instruction practices would be warranted. Few teachers demonstrated a deeper understanding of fluency, beyond providing a definition and naming assessment and instructional methods. Clearly, professional development should delve deeper than the definition and methods, and promote a more sophisticated understanding of importance of fluency, the skills needed for fluent reading, and methods for evaluating students' developing fluency.

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APPENDIX A Scoring Rubric for Teacher Knowledge of Reading Fluency Survey

0	1	2	3
General meaning of assigned ratings			
Shows no knowledge or provides insufficient detail to tell how much they know.	Shows little knowledge and some information may be incorrect.	Shows some or acceptable level of knowledge—knowledge at a surface level.	Shows excellent, expert level of knowledge—knowledge at a deep, detailed level.
Scoring rubric for question 1: what is reading fluency?			
No answer or incorrect answer.	Response relates to one area of reading fluency (accuracy, automaticity, and prosody).	Response relates to two areas of reading fluency (accuracy, automaticity, and prosody).	Includes all three areas in definition.
	Response relates to more than one area, but only one area is explained correctly.	Response relates to more than two areas, but only one area is explained correctly or completely.	Response is accurate and complete.
Scoring rubric for question 2: why is it important for children to develop reading fluency?			
Specific indicators:			
Indicates reading fluency is important.	Indicates reading fluency is important for comprehension but does not provide any details.	Indicates reading fluency is important for comprehension. Provides additional details, but not how or why fluency affects comprehension.	Indicates reading fluency is important for comprehension. Provides additional details and explains how or why fluency affects comprehension (e.g., says readers will devote less attention to decoding).
Vague and general. Lacks details.			

(*Continued*)

APPENDIX A. Continued

0	1	2	3
Scoring rubric for question 3: what knowledge and skills do children need to become fluent readers?			
Specific indicators:			
Answer incorrect.	Indicates just one area with no additional details.	Provides more areas, but either at either the word level or language level.	Provides sufficient areas to cover both the word and language levels.
Vague and general. Doesn't answer the question. Focuses on what teachers do, not what students need to learn.		Lacks sufficient detail.	Complete and correct answer.
Scoring rubric for question 4: how can reading fluency be assessed?			
Specific indicators:			
Answer incorrect.	Indicates just one area with no additional details.	Indicates two areas or just DIBELS with no detail about specific subtests or procedures.	Indicates multiple methods that address three areas of fluency.
Vague and general.		Lacks sufficient detail.	Provides names of specific assessments with sufficient detail.
Doesn't answer the question—doesn't tell how to assess or tells about instruction.			
Scoring rubric for question 5: rating of the methods indicated			
Specific indicators:			
0 research-based methods mentioned.	1–2 research-based methods mentioned.	More than one research-based method mentioned and addresses more than one component (accuracy, automaticity, prosody).	Three or more research-based methods are mentioned, and methods address all components of fluency (accuracy, automaticity, prosody).
Methods mentioned do not address reading fluency.	Methods only address one component of reading fluency.		

APPENDIX B Sample Responses from Teacher Knowledge of Reading Fluency Survey

0	1	2	3
General meaning of assigned ratings			
Scoring rubric for question 1: what is reading fluency?			
A program designed to enhance five components of learning how to read.	So that when asked to read, can read a text and decode the words.	The ability to read with expression and at an appropriate rate.	Reading accurately at a comfortable rate and using intonation and expression to lead to comprehension.
Scoring rubric for question 2: why is it important for children to develop reading fluency?			
To prepare students for success.	Research has found that fluency directly affects reading comprehension.	There is a high correlation between fluency and comprehension. If students are fluent, they can focus on comprehension instead of thinking about decoding.	The main reason is how much fluency is connected to comprehension. If a child reads words incorrectly or slowly, he is unlikely to understand. Reading accurately and smoothly with expression makes comprehension easier and makes reading more enjoyable.
Scoring rubric for question 3: what knowledge and skills do children need to become fluent readers?			
A love of reading.	Decoding skills.	Children need to be able to sound out words correctly. Without good decoding skills, they will never be fluent readers. They also need to know their sight words.	To become fluent readers, children need a solid foundation in phonemic awareness, alphabet knowledge, and decoding skills. They need to be automatic with their skills, and they need to be able to read text without hesitations. They also need to be able to understand the words they read so they can figure out other words quickly.

(*Continued*)

APPENDIX B. Continued

0	1	2	3
Scoring rubric for question 4: how can reading fluency be assessed?			
FCAT	One-minute timings.	One-minute readings (for speed), listening for prosody	DIBELS is a quick way to assess rate and accuracy. You can also use running records to figure out which words need work. Also, you can listen to how a child sounds when they read. Does it sound smooth? Do they read with expression?
Scoring rubric for question 5: rating of the methods indicated			
Centers, computers, games, etc.	Rereading text.	Timed readings, rereading familiar text, practicing sight words.	A teacher should model fluent reading so that students can understand the concept of being fluent and how a fluent reader sounds. Having the students do timed re-readings will build accuracy and improve rate and confidence.