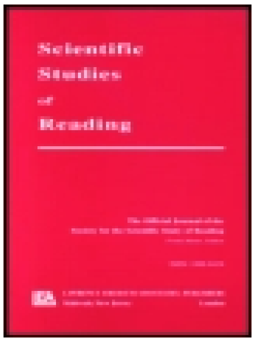

SCIENTIFIC STUDIES OF READING

ISSN: 1088-8438 (Print) 1532-799X (Online) Journal homepage: https://www.tandfonline.com/loi/hssr20

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To cite this article: Shayne B. Piasta , Carol McDonald Connor , Barry J. Fishman & Frederick J. Morrison (2009) Teachers' Knowledge of Literacy Concepts, Classroom Practices, and Student Reading Growth, SCIENTIFIC STUDIES OF READING, 13:3, 224-248

To link to this article: https://doi.org/10.1080/10888430902851364

Published online: 12 May 2009.

SCIENTIFIC STUDIES OF READING, *13*(3), 224–248

ISSN: 1088-8438 print / 1532-799X online
DOI: 10.1080/10888430902851364

Routledge
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Teachers' Knowledge of Literacy Concepts, Classroom Practices, and Student Reading Growth

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We examined the relations of teacher knowledge (n = 42 first-grade teachers), explicit decoding instruction provided, and students' (n = 437) word-reading gains. Results revealed an interaction between teacher knowledge and observed decoding instruction: For students of more knowledgeable teachers, more time in explicit instruction predicted stronger word-reading gains. For students of less knowledgeable teachers, more time in explicit instruction was associated with weaker skill gains. Findings highlight the importance of teachers' specialized body of knowledge about reading as it informs effective instruction.

Although there are encouraging trends in students' achievement across the globe (Mullis, Martin, Kennedy, & Foy, 2007), too many children fail to learn to read proficiently, especially children living in poverty and children from certain ethnic groups. Teacher quality has recently received much attention as a means of ameliorating this problem (Commission of the European Communities, 2007; Stigler & Hiebert, 1999; U.S. Department of Education, 2004). For example, the No Child Left Behind Act of 2001 (U.S. Public Law 107-110) calls for "highly qualified" teachers in every classroom. However, there has been disagreement about what "highly qualified" means. Although many definitions have focused principally on educational preparation and certification, teachers' years of education and qualifi-

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cations have not emerged as strong predictors of teacher efficacy with regard to improving student achievement in either early elementary (e.g., Connor, Son, Hindman, & Morrison, 2005) or high school (Goldhaber & Brewer, 2000).

In this study, we propose that a key element of teacher quality is the specialized knowledge teachers utilize when teaching. It has been suggested that the teaching profession is analogous to the medical profession (Whitehurst, 2002). However, others claim that this is an invalid comparison because, as Finn and Kanstoroom (2001) observed, "doctoring rests, on a solid foundation of specialized professional knowledge that is scientifically buttressed by reliable reputable research. … Unfortunately this is not the case in education" (p. 158). Still, accumulating literacy and other education research demonstrates that teaching reading effectively may not be as intuitive or based on common sense as has been generally accepted (Connor, Morrison, Fishman, Schatschneider, & Underwood, 2007; Connor, Piasta, et al., 2009; Littlewood, 2001) and that a specialized body of knowledge about literacy concepts may be a prerequisite of effective teaching (Moats, 1994, 1999; Moats & Lyon, 1996). The purpose of this study was to examine whether specialized knowledge about language and literacy concepts specific to early reading skill acquisition relates to U.S. first-grade teachers' practice and whether this knowledge interacts with practice to impact their students' literacy learning.

There is a growing consensus that rather specialized knowledge is necessary for teaching reading effectively, particularly for alphabetic languages such as English (e.g., Association for Childhood Education International, 2007; Brady & Moats, 1997; Fillmore & Snow, 2000; International Reading Association, 2000, 2003; Moats, 1994, 1999, 2000; Moats & Lyon, 1996). This specialized knowledge includes understandings of the general developmental progression of literacy learning (Adams, 2001), knowledge of the alphabetic principal including phonological awareness and phonics (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001), specific reading comprehension strategies and how to teach them (National Reading Panel, 2000), and the contribution of students' vocabulary (Beck, McKeown, & Kucan, 2002; Biemiller & Boote, 2006) and fluency (Therrien, 2004) to proficient reading skills.

It is important to note that such knowledge includes an understanding of language and print structure (Moats, 2000). Current theories of reading emphasize the necessity of the alphabetic principle to link phonological, orthographic, and semantic knowledge, particularly in the beginning stages of literacy (e.g., Adams, 1990; Ehri, 1987, 1998; Perfetti, 1985; Rayner et al., 2001). Thus, teachers' code-related knowledge of the alphabetic principle and mappings between language and print, coupled with knowledge of relevant instruction practices, would appear essential for effective early reading instruction.

Documenting teachers' knowledge about language and literacy concepts, accumulating research has shown that teachers generally exhibit low levels of knowledge about language and literacy concepts, literacy development, and literacy pedagogy (Bos, Mather, Dickson, Podhajski, & Chard, 2001; Mather, Bos, & Babur, 2001; Moats, 1994; Moats & Lyon, 1996; Troyer & Yopp, 1990). In addition, teachers are often unable to accurately calibrate their knowledge. For example, many teachers overestimate the level of their knowledge (Cunningham, Perry, Stanovich, & Stanovich, 2004; Spear-Swerling, Brucker, & Alfano, 2005). Nor does their own general literacy ability necessarily translate into explicit knowledge of language and print structure (McCutchen, Harry, et al., 2002). Altogether, researchers have generally concluded that teacher education alone, as currently practiced, is not enough to establish critical knowledge about early reading concepts and instruction. Appropriate and intensive professional development appears necessary to ensure that teachers have sufficient levels of critical knowledge needed to impact student achievement (Cunningham et al., 2004; McCutchen, Abbott, et al., 2002; McCutchen, Harry, et al., 2002; Moats & Foorman, 2003; Spear-Swerling & Brucker, 2004; Spear-Swerling et al., 2005).

Additional research has shown the impact of professional development and teacher preparation on teachers' knowledge (Bos, Mather, Narr, & Babur, 1999; Foorman & Moats, 2004; McCutchen, Abbott, et al., 2002; McCutchen, Harry, et al., 2002; Moats & Foorman, 2003; Spear-Swerling & Brucker, 2003, 2004). Importantly, this research has attempted to link teachers' knowledge to student outcomes. For example, Bos et al. (1999) showed that students of teachers who received professional development aimed at increasing their literacy content knowledge showed greater gains in their letter-sound correspondence, spelling, and fluency skills than did students whose teachers did not receive professional development. This study, however, assumed there was a link between the professional development teachers received and increases in their knowledge; teacher knowledge was not directly assessed.

Spear-Swerling and Brucker (2004) measured teacher knowledge directly. They found that teachers' knowledge after receiving professional development predicted growth in tutored students' word reading scores. This outcome, however, was only one of five assessed; no significant relations were found for students' growth in letter-sound correspondence knowledge, reading of irregular words, or spelling of regular and irregular words. Similarly, Foorman and Moats (2004) found a systematic positive relation between teachers' literacy concept knowledge and one measure of students' end-of-year reading abilities after teachers had received professional development, and McCutchen, Harry, et al. (2002) found significant positive correlations between teachers' literacy knowledge and kindergarteners' word reading outcomes. However, McCutchen, Harry, et al. found no relation between teacher knowledge and first and second graders' vocabulary, reading comprehension, spelling or writing fluency skills.

Overall, the impact of teacher knowledge on student literacy outcomes has been difficult to discern, perhaps confounded by the various limitations of relevant studies. Most studies focused exclusively on student outcomes, without considering students' initial skill levels or the role of teacher knowledge in informing instruction to promote reading skill growth. Limitations in available analytic strategies forced researchers to either aggregate student data to the classroom level or ignore the shared variance within classrooms and nonindependence of teacher knowledge scores to link student and teacher variables. Finally, although we might assume that teachers' knowledge affects student learning to the extent that the knowledge shapes and improves literacy instruction, most studies did not include observations of actual classroom instruction. Instead, they regarded the classroom as a "black box."

Ignoring the role of classroom instruction and its effect on student outcomes is particularly troubling, given accumulating evidence demonstrating the impact of instructional practices on student learning (Connor et al., 2007; Connor, Piasta, et al., 2009; National Reading Panel, 2000; Roberts & Meiring, 2006; Torgesen et al., 2001). In descriptive and correlational studies (e.g., Foorman & Moats, 2004; Foorman & Schatschneider, 2003), results indicate that students whose teachers used evidence-based teaching techniques in their classrooms had generally stronger reading skills than did students whose teachers used teaching techniques that were not evidence-based. Explicit decoding instruction, in particular, appears to be a key element in promoting students' literacy gains (Connor, Jakobsons, Crowe, & Granger, 2009; Connor, Morrison, & Katch, 2004; Foorman et al., 2006; National Reading Panel, 2000). Yet, as many of these studies indicate, many students still do not receive enough instruction of these types.

One could argue that to teach effectively, teachers not only must understand that explicit instruction is important but also grasp the concepts to be taught (e.g., the mappings between oral and written language) and possess the specialized knowledge to teach these concepts successfully. In other words, maximizing students' reading achievement may require explicit reading instruction as implemented by highly knowledgeable teachers. A similar hypothesis has been set forth by McCutchen and colleagues. McCutchen, Abbott, et al. (2002) showed that the use of evidence-based practices, defined as the amount of time teachers spent in explicit phonological, orthographic, and comprehension activities, could be increased via professional development. Moreover, positive relations were found between the amount of explicit phonological instruction received by kindergarten students and their phonological awareness and letter-sound knowledge. In this study, it was hypothesized that knowledge gained from professional development contributed to more effective practice (i.e., greater amounts of time in evidence-based practices) and thus stronger student outcomes. A second study (McCutchen, Harry, et al., 2002) directly explored the proposed associations among teacher knowledge, classroom practices, and student outcomes. No significant relations among teacher knowledge, amount of explicit instruction, and student literacy outcomes were found for either first or second grade. McCutchen, Harry, et al. (2002) did, however, find that kindergarten students who received greater amounts of explicit phonological awareness instruction demonstrated greater word-reading skills and that greater teacher knowledge predicted greater amounts of time spent in explicit phonological awareness activities.

Taken together, this body of research shows equivocal results for the importance of teachers' knowledge about literacy. One reason may be that, with a single exception, no study systematically examined the relation between teachers' knowledge about language and literacy concepts and their classroom practices while examining the effect of classroom practices on students' literacy gains. Rather, studies examined the effect of teacher knowledge on either student outcomes or classroom practice, or they examined classroom practice effects on student outcomes. Only one study (McCutchen, Harry, et al., 2002) examined the entire system simultaneously and, even then, results reported simple correlations, data were aggregated at the classroom level, and only students' outcomes, not growth in skill, were considered.

In this study, we first sought to detail the nature and variability in first-grade teachers' knowledge about early literacy concepts (e.g., phonological awareness, alphabetic principle, etc.). We then examined the amounts and types of decoding instruction teachers provided and the effect of this instruction on students' literacy skill growth as a function of teachers' knowledge about language and early literacy. The following research questions guided this latter inquiry:

1. Do either teachers' assessed knowledge or the amount of explicit decoding instruction students receive directly predict students' word identification gains?
2. Does teacher knowledge predict use of explicit decoding instructional practices?
3. Do teacher knowledge and use of explicit instruction interact in predicting students' word identification gains?

We hypothesized that the link between teacher knowledge and student learning would not be direct. Rather, we predicted that the effect of teachers' knowledge would impact student literacy outcomes as a function of the instruction students received. Thus, students' literacy skill gains would not be predicted by teacher knowledge alone but by teacher knowledge as it informed classroom practices. We conjectured that the decoding instruction provided by teachers with higher levels of knowledge about language and early literacy concepts would be more effective (i.e., associated with stronger student word identification growth) than would similar amounts of instruction provided by teachers with less knowledge.

METHOD

This study was undertaken within the context of a larger study, the Individualizing Student Instruction (ISI) Project. The full results of the random control trial are reported in Connor et al. (2007) and Connor, Piasta, et al. (2009). The ISI Project was designed to test the effect of student characteristics by instruction interactions found by Connor et al. (2004) and others. An impact on student reading gains above and beyond the ISI effect was anticipated for teacher knowledge and explicit instruction, however. Hence, for this study, we considered teachers in both the ISI treatment and control conditions and focused on teachers' knowledge at the beginning of the school year, which was assessed prior to the commencement of the ISI intervention protocol. Our intention was to examine the relations among teacher knowledge, classroom practice, and student outcomes across the full ISI sample, with no expectation that these relations would differ based on intervention condition. However, given the main effect of ISI treatment (see Connor et al., 2007) and enhanced professional development provided to ISI teachers, we statistically controlled for intervention effects and examined possible interactions with the ISI treatment in analyses.

Participants

Six hundred sixteen students in 49 first-grade classrooms in 10 ethnically and socioeconomically diverse schools participated in the larger ISI study. These 10 schools, located in a school district in northern Florida, were nominated for participation in the ISI Project by district officials. Half of the schools were participating in the Florida Reading First program, a federally funded initiative run by school districts and designed to improved literacy instruction in historically low income and underperforming schools. Schools were matched on percentage of children qualifying for the federal free or reduced-priced lunch (FRL) program, a commonly used indicator of socioeconomic status, third-grade reading scores on the Florida Comprehensive Achievement Tests, and Reading First status (see Table 1 for descriptive data for each school). One member of each school pair was randomly assigned to the ISI treatment condition, as were all teachers participating in the study at that school.

Teachers at schools in the ISI treatment condition received Assessment to Instruction (A2i) Web-based software, spring and fall workshops (totaling 9 hr), and teacher training, including biweekly classroom-based sessions, all designed to facilitate differentiated instruction in the classroom (see Connor et al., 2007; Connor, Piasta, et al., 2009 for detailed descriptions of ISI Project procedures). The A2i software did not replace teachers' classroom curricula or require the use of specific literacy activities. Rather, A2i provided broad recommendations for each child in the classroom regarding the amount of time to be spent on either code-focused (i.e., aimed at increasing phonological decoding and word reading) or meaning-focused (i.e., aimed at extracting and constructing meaning from print) instructional activities, based on their language and literacy skills. Also recommended was the degree to which these activities ought to be scaffolded by

TABLE 1
School and Teacher Descriptives

	ISI Treatment	*ISI Control*	*Total Sample*
School characteristics			
n	5	5	10
No. participating in Reading First	2	3	5
Core curriculum			
No. using Open Court	4	4	8
No. using Reading Mastery	1	1	2
No. of Grade 1 classrooms	25	27	52
% of children with FRL status			
Range	29–96%	24–93%	24–96%
M (*SD*)	68.60% (25.01)	59.80% (30.44)	64.20% (26.67)
M (*SD*) Grade 3 FCAT reading score	308.20 (25.34)	305.40 (26.55)	306.80 (24.51)
Teacher characteristics			
n	19	23	42
% at Reading First schools	57.89%	39.13%	47.62%
% female	89.00%	91.00%	90.50%
Ethnicity			
% White	47.00%	78.00%	64.30%
% African American	53.00%	22.00%	35.70%
Teacher education			
% with bachelor's degree	52.60%	87.00%	100.00%
% with master's degree	47.40%	13.00%	28.60%
Total years of teaching experience			
Range	0–31	1–32	0–32
M (*SD*)	12.83 (11.62)	10.22 (8.07)	11.40 (9.80)
Years of Grade 1 teaching experience			
Range	0–25	0–22	0–25
M (*SD*)	4.49 (5.93)	5.87 (5.28)	5.24 (5.61)
M (*SD*) TKA:LP score	18.84 (7.17)	27.26 (4.80)	23.45 (7.27)

Note. ISI = Individualizing Student Instruction Project; FRL status = eligible for free or reduced price lunch program; FCAT = Florida Comprehensive Assessment Test; TKA:LP = Teacher Knowledge Assessment: Language and Print.

the teacher. ISI Project professional development focused on how to individualize instruction within the classroom, using small groups and activity centers. This was coupled with training on using assessment to guide evidence-based instruction.

Our study involved 42 first-grade teachers (descriptives presented in Table 1). Of the 49 teachers who began the study, 3 participated in the development of the Teacher Knowledge Assessment: Language and Print (described next) and were not included in these analyses. One teacher failed to complete the fall administration of the Teacher Knowledge Assessment, and 3 teachers withdrew from participation over the course of the year. The 4 teachers withdrawing from the study had significantly lower fall Teacher Knowledge Assessment scores than those teachers who remained, Welch's test, $F(1, 12.163) = 40.823$, $p < .001$.

All first-grade students in participating teachers' classrooms were invited to participate in the ISI Project, and parental consent was obtained for 76% of these students. To conserve resources while maintaining a representative distribution of student abilities, target children for classroom observations were randomly selected from the complete group of participating children in the following manner. Within each classroom, students were rank ordered by their fall Woodcock–Johnson Tests of Achievement–III (WJ) Letter-Word Identification raw score (described next) and divided into three groups (i.e., weak, average, and strong readers). Four students from each group were randomly selected as target students. If 12 participating students did not exist in a particular classroom, all participating students were designated as target students. In all, 480 students were observed in their classroom at least once. Four hundred sixty-seven target students were observed at the winter time point, the data analyzed for our study. Ten of these students were in classrooms of teachers without Teacher Knowledge Assessment scores and correspondingly dropped from analyses. Of the remaining target students, 20 did not complete the fall and spring assessments. Thus, our study reports data from 437 target students. Approximately 50% of the target students were female, and 44.2% of these students were African American, 40.2% were White, and 16.6% were of other or unknown ethnicities. Forty-one percent qualified for FRL. Given the scores provided in Table 2, the achievement of our sample was commensurate with the larger population (i.e., standard scores and standard deviations typical of the standardization sample).

TABLE 2
Descriptive Statistics for Student Participants

	M	*SD*	*Range*
Time 1			
WJ-LWid W score	414.77	32.41	334–519
WJ-LWid standard score	105.50	17.43	51–149
WJ-Voc W score	480.48	11.12	444–513
WJ-Voc standard score	103.28	13.43	70–139
Time 2			
Minutes of decoding instruction	7.43	10.78	0–95
Time 3			
WJ-LWid W score	456.87	25.96	357–525
WJ-LWid standard score	110.72	14.10	60–149

Note. Times 1, 2, and 3 correspond to fall, winter, and spring, respectively. Standard score test sample $M = 100$ ($SD = 15$). WJ-LWid = Woodcock–Johnson Letter-Word Identification subtest; WJ-Voc = Woodcock–Johnson Picture Vocabulary subtest.

Assessments

Students' language and literacy skills were assessed in the fall (Time 1) and spring (Time 3) of the 2005–2006 school year. Students were assessed individually by trained research assistants in a quiet place near the students' classrooms. The assessment battery included tests from the WJ (Woodcock, McGrew, & Mather, 2001). The WJ was selected because it is widely used in schools and for research, and is psychometrically strong (reliabilities on the tests used ranged .81–.94). Students' word-reading skills were assessed using the Letter-Word Identification subtest (word identification). The Word Identification subtest asks students to identify letters of the alphabet by name and read lists of increasingly difficult words. Students' expressive vocabulary was assessed using the Picture Vocabulary subtest, which required students to name pictures of increasingly unfamiliar objects. For analyses, word identification and vocabulary raw scores were converted to W scores. W scores represent ability on a Rasch scale (i.e., equal interval measurement scale) centered at 500 or the typical ability level of a 10-year-old child. Descriptive statistics for these measures are presented in Table 2.

Teachers' code-related knowledge was assessed at the beginning of the school year using the Teacher Knowledge Assessment: Language and Print. The Teacher Knowledge Assessment was designed for this study to assess teachers' understanding of English phonology, orthography, and morphology, as well as important concepts of literacy acquisition and instruction. Various reasons led us to focus almost exclusively on teachers' code-related knowledge. Many previous studies have assessed teachers' knowledge of language and print structure, attempting to discern a direct relation with student outcomes, and such knowledge is theoretically important for effective teaching of decoding (Moats, 2000). Previous use of similar teacher knowledge surveys (Bos et al., 2001; Mather et al., 2001; Moats, 1994; Moats & Foorman, 2003) allowed us to adapt validated measures to create our Teacher Knowledge Assessment.

Items directly borrowed from other teacher knowledge surveys were pilot tested with veteran teachers, with 30 items retained. Four additional multiple-choice questions and a short answer section were devised to more fully assess knowledge of particular concepts (e.g,. onsets/rimes, morphemes, syllables). The full Teacher Knowledge Assessment thus consisted of 34 multiple-choice items (e.g., What is the second sound in the word *queen*? What type of task is the following: What word would you have if you said *taught* without the /t/ sound?) and 11 short-answer items (e.g., List the six syllable types.), and had a reliability of $\alpha = .87$. The measure is available from the first author upon request. Scores on the Teacher Knowledge Assessment ranged from 9 to 36 ($M = 23.45$, $SD = 7.27$; see Table 1).

Classroom Observations

For the ISI Project, classrooms were observed at three time points during the school year—fall, winter, and spring. The winter (Time 2) observations were utilized in our study because these were the most consistent across schools, based on observers' records. This is consistent with other research suggesting that early winter observations tend to be most representative of teachers' practice (Hamre, Pianta, Downer, & Mashburn, 2007). Observations were scheduled with teachers ahead of time, at their convenience. Observations took place during teachers' dedicated literacy blocks (although classrooms were observed for a full day at the winter time point, activities occurring outside the literacy block were not within the scope of our study and not included in analyses). At two schools, children changed classrooms during their literacy blocks, resulting in observation of 48 classes. During classroom observations, two video cameras were used to record all classroom activities taking place. Research assistants wrote detailed descriptions of all target students present in the classroom, for later identification during coding, and completed field notes regarding classroom activities (i.e., those which might not be captured on video, including details of when/why students entered or left the classroom, explanations of events or activities that took place outside of the cameras' views, and descriptions of worksheets and other activities whose content could not be seen on camera).

The classroom video observations were coded in the laboratory using the Noldus Observer Pro software package (Noldus Information Technology, 2001). The coding system was expanded and adapted from the Pathways to Literacy Coding scheme (Connor, Morrison, & Slominski, 2006) and was designed to capture the precise amount of time, in minutes:seconds, that target students spent in various classroom activities (see Connor et al., 2007; Connor, Piasta, et al., 2009, for complete description of the full coding system). All instructional activities lasting 15 sec or longer occurring during the literacy block were identified and timed. Noninstruction—which included students' off-task behavior, time spent waiting, transitions, and the organizational time teachers spent explaining classroom activities, rules, and routines—was also time-coded. Coding was conducted at the level of the child; thus, the coding system allowed for the fact that students within the same classroom did not necessarily receive the same learning opportunities. For example, target Student A might have been observed independently reading a book in the library corner, whereas target Student B was observed participating in a small group in which the teacher was providing explicit instruction in grapheme–phoneme correspondences. Twelve percent of observations were checked for reliability among coders, with an average Cohen's kappa of .76.

Literacy activities with content relevant to decoding instruction were of particular interest in our study. Explicit decoding instruction has been linked to enhanced reading outcomes for students (Connor, Jakobsons, et al., 2009; Connor et al., 2004; Foorman et al., 2006). In addition, this kind of literacy instruction requires specialized knowledge that is not generally known outside of literacy research and education and is theoretically linked to the code-related knowledge measured by the

Teacher Knowledge Assessment. The amount of instruction coded as explaining and/or demonstrating strategies for decoding new words (e.g., using grapheme–phoneme correspondences, sounding out or using word families to decipher unfamiliar words; see Figure 1) was collapsed into a single variable representing the total amount of time a student spent in such activities. On average, students received 7.43 min of explicit decoding instruction (see Table 2). Note that merely reading words or connected text was not considered explicit instruction and thus not included in the decoding instruction totals. Thus, Student A, described previously, who was reading a book, was not receiving explicit instruction although she was involved in a literacy activity whereas Student B was receiving explicit decoding instruction.

RESULTS

Hierarchical Linear Models (Raudenbush & Bryk, 2002) were used to control for the nested nature of the data, students nested within observed classes (n =

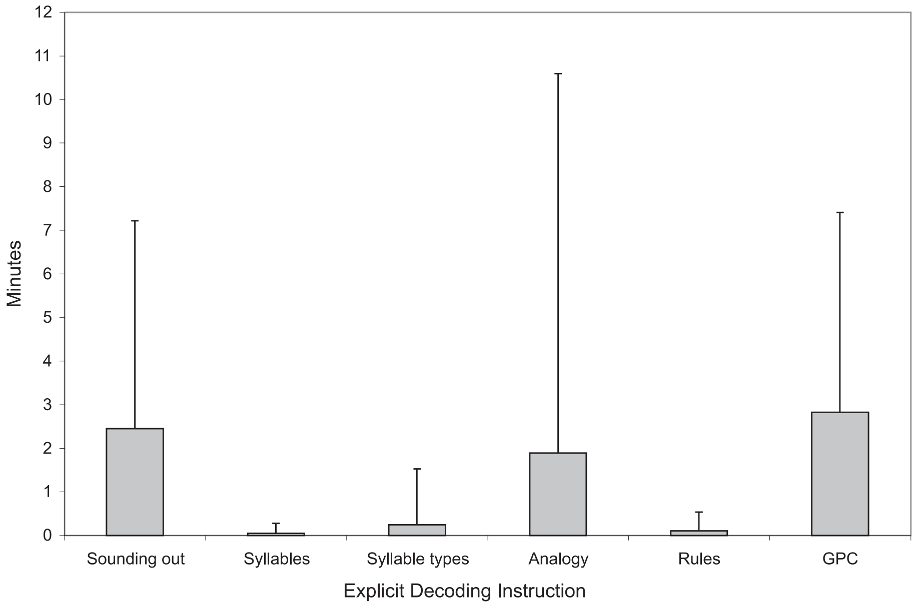

FIGURE 1 Mean (+ 1 *SD*) amounts of specific decoding instructional activities. *Note.* Sounding out = using grapheme-phoneme correspondences to sound out words; Syllables = breaking words into pronounceable syllables that are then blended; Syllable types = using the six syllable types to determine vowel pronunciations in words; Analogy = using word families to identify unknown words; Rules = using particular phonics or spelling rules during decoding; GPC = teaching/learning individual grapheme-phoneme correspondences. Full code descriptions available from the first author upon request.

48)[1] within schools. Preliminary analyses showed little variability among schools (intracluster correlation [ICC] for word identification = .071). The majority of the variance was explained by differences in school-level socioeconomic status (i.e., percentages of children receiving FRL; conditional ICC = .033). Thus, more parsimonious two-level models in which school-level socioeconomic status was controlled were utilized for all analyses (ICC = .247)

Residualized gain was used to assess the relations of teacher knowledge and practice to students' Time 3 word identification scores after controlling for Time 1 scores (Zumbo, 1999). All models also controlled for students' Time 1 vocabulary scores, as this measure represented the sole pretest difference between students in the ISI treatment and control conditions (control students significantly outscored students in the treatment condition; see Connor et al., 2007). Student-level variables thus included Time 1 and Time 3 word identification scores, Time 1 vocabulary scores, and the amount of explicit decoding instruction received.

Teacher Knowledge Assessment scores, ISI treatment status, and schoolwide percentage of children receiving FRL were entered as fixed effects at Level-2. ISI treatment was modeled to control for its impact on student outcomes (see Connor et al., 2007). As anticipated, effects of teacher knowledge and instructional practices were seen above and beyond the ISI treatment, and these effects were similar for treatment and control teachers (i.e., no significant two- or three-way interactions involving treatment condition). Moreover, results were similar when conducted solely using ISI control teachers. Hence, for all results reported next, the impact of treatment was a shift in the intercept (denoted by γ_{02} in Tables 3–8), with students of treatment teachers generally outperforming students of control teachers by approximately 4 to 8 points.

All continuous variables were grand-mean centered, allowing coefficients to be interpreted relative to the sample mean. Note that Hierarchical Linear Model (HLM) coefficients, represented by γ, are interpreted similar to traditional multiple regression unstandardized (B) coefficients. Also, although potential two- and three-way interactions were tested, interactions other than those reported were nonsignificant and trimmed to create more parsimonious models.

Nature and Variability in Teacher Knowledge and Use of Explicit Decoding Instruction

Teachers ranged in their knowledge of language and literacy, with scores of 9 to 36 on a scale of 45. The average score of 23.45 is equivalent to answering 52% of

[1]Six of the 42 teachers participating in the study were responsible for two reading classes, resulting in the 48 observed classes. Similar to the school-level analyses reported in text, three-level models (students nested in observed classes nested in teacher) found more variance between observed classes than between teachers, particularly once school-level FRL percentages were controlled (conditional ICC for WJ Letter-Word Identification subtest = .033 at the teacher level, .189 at the class level). Thus, observed classrooms, and not teachers, were used as the Level-2 units to model the class variance.

questions correctly. Item analyses showed that, on average, teachers were most successful in answering questions pertaining to instructional practices (5 items; 63.33% correct) and phonics (12 items; 62.10% correct), followed by onset/rimes (2 items; 58.34% correct), phonological awareness (7 items; 55.10% correct), and morphology (4 items; 42.86% correct). They were least correct responding to items about syllables (15 items; 37.46% correct). Teacher knowledge was unrelated to teachers' level of education and overall experience, but positively associated with teachers' grade 1 teaching experience (see Table 3). Students' Time 1 word identification scores were unrelated to their reading teachers' Teacher Knowledge Assessment scores, $\gamma_{01} = .0279$, $t(46) = 0.701$, $p = .487$; and $\gamma_{01} = 0.129$, $t(46) = 0.501$, $p = .619$, respectively, demonstrating that students were not systematically placed with teachers with more or less knowledge based on incoming scores.

Overall, during their literacy blocks, students spent an average of 94.67 min in instructional activities ($SD = 52.70$) and an additional 56.56 min in organizational and noninstructional activities ($SD = 44.29$). As seen in Table 2, students received varying amounts of explicit decoding instruction during this time. The average student received approximately 7.43 min of explicit decoding instruction, together with an additional 2.84 ($SD = 5.97$) min of word reading practice and 19.39 ($SD = 25.21$) min of connected text reading. Some students spent more than half of their literacy blocks involved in decoding and word-reading activities. Total amounts of explicit decoding instruction varied both within and between reading groups (ICC = 0.454).

Figure 1 details the activities taking place during decoding instruction. Most of the time was spent learning grapheme–phoneme correspondences ($M = 2.82$ min), using grapheme–phoneme correspondences to sound out words ($M = 2.43$ min), and decoding words through use of analogy or word families ($M = 1.88$ min). The large standard deviations shown in Figure 1, however, depict substantial variation

TABLE 3
Correlations Among Teacher-Level Variables

Variable	*1*	*2*	*3*	*4*	*5*	*6*
1. TKA:LP	—	–.583**	–.399**	–.143	.084	.410**
2. ISI treatment		—	.495**	.378*	.134	–.124
3. FRL level			—	.126	.053	–.124
4. Master's degree				—	.241	.001
5. Total years of teaching experience					—	.597**
6. Years of Grade 1 teaching experience						—

Note. TKA:LP = teacher knowledge assessment score; ISI = Individualizing Student Instruction Project; FRL = schoolwide percentage of students participating in the free or reduced-priced lunch program.

*$p < .05$. **$p < .01$.

in the amounts of these three types of instruction received by individual children. Less than 1 min of instruction, on average, focused on using syllables, syllable types, or phonics/spelling rules to aid in decoding.

Table 4 provides the correlations among student-level variables. Amount of decoding instruction received was weakly and negatively related to students' word identification scores. That is, students with lower scores tended to receive more decoding instruction than did students with higher scores.

Relations Among Teacher Knowledge, Instructional Practices, and Student Reading Gains

Direct relation of teacher knowledge with student reading gains. Results for the model examining the direct relation of Teacher Knowledge Assessment scores to students' spring word identification are shown in Table 5. Teacher Knowledge Assessment scores did not significantly predict residualized change in students' word identification scores, $\gamma_{03} = 0.275$, $t(44) = 1.373$, $p = .177$, once fall scores, treatment status, and school FRL levels were controlled.

Direct relation of instructional practices with student reading gains. Results for the model examining the direct relation of explicit decoding instruction to students' spring word identification is provided in Table 6. Decoding instruction did not significantly predict residualized change in students' word identification scores, $\gamma_{10} = -0.049$, $t(431) = -0.595$, $p = .552$, after controlling for fall scores, treatment status, and school FRL levels.

Relations between teacher knowledge and practices. Teacher Knowledge Assessment scores did not predict the amounts of explicit decoding instruction teachers provided to their students once fall scores, treatment status, and school FRL levels were controlled, $\gamma_{03} = 0.122$, $t(44) = 0.688$, $p = .495$ (see Table 7 for full model results). These results did not change when Teacher Knowledge As-

TABLE 4
Correlations Among Student-Level Variables

Variable	*1.*	*2.*	*3.*	*4.*
1. Amount of decoding instruction	—	–.135**	–.119*	–.114*
2. Fall WJ letter-word identification W score		—	.444*	.791**
3. Fall WJ picture vocabulary W score			—	.380**
4. Spring WJ letter-word identification W score				—

Note. WJ = Woodcock–Johnson Tests of Achievement–III.
*$p < .05$. **$p < .01$.

TABLE 5
Hierarchical Linear Modeling Results for Direct Relation of Teacher Knowledge to Student Word Identification Gains

Variable	*Coefficient*	*SE*	*df*	*p*
Time 3 WJ-LWid intercept (γ_{00})	454.119	1.994	44	<.001
Child-level variables				
Time 1 WJ-LWid (γ_{10})	0.625	0.027	431	<.001
Time 1 WJ-Voc (γ_{20})	0.103	0.078	431	.185
Classroom-level variables				
FRL level (γ_{01})	–0.021	0.054	44	.696
ISI treatment (γ_{02})	6.582	3.348	44	.055
TKA:LP (γ_{03})	0.275	0.200	44	.177
Random Effects	*Variance*	χ^2	*df*	*p*
Classroom level (U_0)	19.493	86.957	44	<.001
Child level (R)	227.465			

Note. Results with robust standard errors reported. Time 3 = spring; WJ-LWid = Woodcock–Johnson Letter-Word Identification subtest; Time 1 = fall; WJ-Voc = Woodcock–Johnson Picture Vocabulary subtest; FRL = schoolwide percentage of students participating in the free or reduced-priced lunch program; ISI = Individualizing Student Instruction Project; TKA:LP = Teacher Knowledge Assessment score.

TABLE 6
Hierarchical Linear Modeling Results for Direct Relation of Instructional Practice to Student Word Identification Gains

Variable	*Coefficient*	*SE*	*df*	*p*
Time 3 WJ-LWid intercept (γ_{00})	454.861	1.857	45	<.001
Child-level variables				
Time 1 WJ-LWid (γ_{10})	0.620	0.027	431	<.001
Time 1 WJ-Voc (γ_{20})	0.107	0.077	431	.164
Time 2 minutes decoding instruction (γ_{30})	–0.049	0.082	431	.552
Classroom-level variables				
FRL level (γ_{01})	–0.030	0.054	45	.579
ISI treatment (γ_{02})	4.860	3.099	45	.124
Random Effects	*Variance*	χ^2	*df*	*p*
Classroom level (U_0)	21.186	90.224	45	<.001
Child level (R)	227.510			

Note. Results with robust standard errors reported. Time 3 = spring; WJ-LWid = Woodcock-Johnson Letter-Word Identification subtest; Time 1 = fall; WJ-Voc = Woodcock-Johnson Picture Vocabulary subtest; Time 2 = winter; FRL = schoolwide percentage of students participating in the free or reduced-priced lunch program; ISI = Individualizing Student Instruction Project.

TABLE 7
Hierarchical Linear Modeling Results for Relation of Teacher Knowledge to Instructional Practice

Variable	*Coefficient*	*SE*	*df*	*p*
Time 2 minutes decoding instruction intercept (γ_{00})	6.172	1.432	44	<.001
Child-level variables				
Time 1 WJ-LWid (γ_{10})	–0.008	0.011	440	.464
Time 1 WJ-Voc (γ_{20})	–0.014	0.035	440	.698
Classroom-level variables				
FRL level (γ_{01})	0.035	0.051	44	.500
ISI treatment (γ_{02})	3.970	2.987	44	.191
TKA:LP (γ_{03})	0.122	0.177	44	.495
Random Effects	*Variance*	χ^2	*df*	*p*
Classroom level (U_0)	47.645	339.165	44	<.001
Child level (R)	66.153			

Note. Results with robust standard errors reported. Time 2 = winter; Time 1 = fall; WJ-LWid = Woodcock–Johnson letter-word identification subtest; WJ-Voc = Woodcock–Johnson Picture Vocabulary subtest; FRL = schoolwide percentage of students participating in the free or reduced-priced lunch program; ISI = Individualizing Student Instruction Project; TKA:LP = Teacher Knowledge Assessment score.

sessment scores alone were considered in the models, $\gamma_{03} = -0.118$, $t(46) = -0.845$, $p = .403$.

Interaction of teacher knowledge and instructional practices. Table 8 presents results for the HLM model including the main effect of Teacher Knowledge Assessment scores, the main effect of explicit decoding instruction, and the cross-level Teacher Knowledge Assessment Scores × Explicit Decoding Instruction interaction. The interaction between Teacher Knowledge Assessment scores and amount of decoding instruction significantly predicted residualized change in students' word identification scores, $\gamma_{11} = 0.045$, $t(429) = 2.6573$, $p = .009$. Figure 2 depicts this relation. In general, for teachers with Teacher Knowledge Assessment scores at the 50th percentile or higher, the more decoding instruction provided, the higher their students scored on the spring administration of the word identification, controlling for fall scores. For teachers in the lowest 25th percentile on the Teacher Knowledge Assessment, however, the more time their students spent in decoding instruction, the worse were their word identification spring scores. Indeed, students receiving the greatest amounts of decoding instruction from teachers with the least amounts of knowledge showed the weakest word identification score growth, on average.

TABLE 8
Hierarchical Linear Modeling Results for Relations of Teacher Knowledge and Instructional Practice to Student Word Identification Gains

Variable	*Coefficient*	*SE*	*df*	*p*
Time 3 WJ-LWid intercept (γ_{00})	453.625	1.893	44	<.001
Child-level variables (γ_{30})				
Time 1 WJ-LWid (γ_{20})	0.626	0.026	429	<.001
Time 1 WJ-Voc	0.099	0.079	429	.208
Time 2 min. decoding instruction (γ_{10})	0.002	0.065	429	.974
Classroom-level variables				
FRL level (γ_{01})	–0.041	0.050	44	.420
ISI treatment (γ_{02})	8.337	3.130	44	.011
TKA:LP (γ_{03})	0.398	0.197	44	.049
Child × Classroom Level interaction				
TKA:LP × Min. Decoding Instruction (γ_{11})	0.045	0.017	429	.009
Random Effects	*Variance*	χ^2	*df*	*p*
Classroom level (U_0)	16.862	83.000	44	.001
Child level (R)	223.791			

Note. Results with robust standard errors reported. Time 3 = spring; WJ-LWid = Woodcock-Johnson Letter-Word Identification subtest; Time 1 = fall; WJ-Voc = Woodcock-Johnson Picture Vocabulary subtest; Time 2 = winter; Min. = minutes; FRL = schoolwide percentage of students participating in the free or reduced-priced lunch program; ISI = Individualizing Student Instruction Project; TKA:LP = Teacher Knowledge Assessment score.

To better understand these results, consider students of ISI treatment teachers. With no explicit decoding instruction, model results show students of teachers with high, average, and low knowledge attaining spring W scores of 461.70, 462.07, and 463.64 (standard scores of approximately 122–123 for students at the mean age of the sample; see Figure 2). Students of teachers with high knowledge who received approximately 18 min of decoding instruction (i.e., 1 standard deviation above the mean), however, attained fitted spring scores of 466.38 (standard score ≈ 125). Students receiving similar amounts of instruction from teachers with average knowledge attained scores of 463.75 (standard scores ≈ 123), which are essentially the same as if they had been provided no explicit decoding instruction. Fitted scores of students who received 18 min of decoding instruction from teachers with low knowledge were only 458.50 (standard scores ≈ 120). Thus, although there was essentially no difference in student scores based on teacher knowledge when no decoding instruction was provided, students provided explicit decoding instruction by teachers with high knowledge stood to gain up to 5 standard score points over students provided such instruction by teachers with low knowledge.

Keep in mind that amount of instruction, teacher knowledge scores, and student outcome variables are continuous. Thus, we have modeled plausible teacher

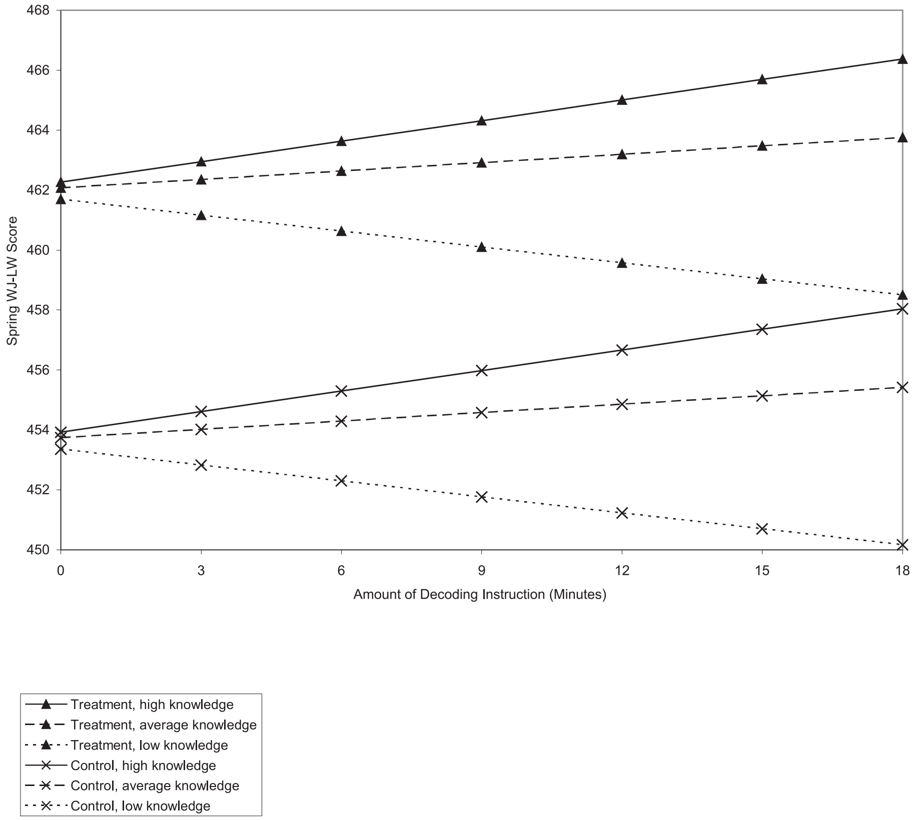

FIGURE 2 Teacher Knowledge × Amount of Decoding Instruction interaction effect on fitted spring WJ-LWid scores. *Note.* Teacher knowledge scores fall at the 25th (low), 50th (average), and 75th (high) percentiles. WJ-LWid = Woodcock–Johnson Letter-Word Identification subtest.

knowledge scores at the 75th, 50th, and 25th percentiles of the sample. However, any combination of scores and amounts of instruction might have been modeled.

DISCUSSION

In directly assessing teacher knowledge, classroom instruction, and student outcomes, our study demonstrated the complex role of first-grade teachers' specialized knowledge regarding language and literacy concepts in promoting students' word reading growth. Contrary to previous findings (e.g., McCutchen, Abbott, et al., 2002; McCutchen, Harry, et al., 2002), we found no evidence that teacher knowledge directly affected students' reading gains. Rather, as we anticipated, students' gains were predicted by the interaction between teacher knowledge and amount of explicit decoding instruction students received. It is important to note that we found that the instruction provided by teachers with higher levels of language and early literacy specific knowledge was significantly more effective in improving students' word-reading skill growth compared to the same amount of instruction provided by teachers with lower levels of knowledge. Indeed, according to our models, the more time teachers with high knowledge scores spent in explicit decoding instruction, the greater was their students' word-reading skill growth. In contrast, the more time teachers with low knowledge scores spent in explicit decoding instruction, the weaker were their students' spring word reading scores, controlling for initial status.

These results expand the growing literature demonstrating the positive impact of providing primary-grade students with explicit reading instruction and learning opportunities (Connor, Jakobsons, et al., 2009; Connor et al., 2004; Foorman et al., 2006; McCutchen, Harry, et al., 2002; National Reading Panel, 2000). Overall, these results indicate that, although specialized knowledge of language and early literacy is essential for teachers of first-grade reading, its influence should be considered within the context of the actual classroom instruction provided.

Teacher Knowledge, Classroom Practices, and Student Reading Gains

Teachers' specialized knowledge for teaching first-grade reading affected students' word-reading growth only to the extent that it was actually enacted in the classroom. Having a highly knowledgeable teacher *or* a great deal of explicit instruction in first grade was not associated with students' word reading growth. Teachers with high scores on the Teacher Knowledge Assessment who did not provide explicit decoding instruction were no more effective in promoting their student's reading skills than were teachers with very low scores on the measure. Moreover, teachers with low knowledge scores who persisted in providing large amounts of decoding instruction tended to produce weaker reading skill growth in students than if the teacher had not provided any explicit decoding instruction at all.

Review of the video-taped observations showed that teachers with low scores on the Teacher Knowledge Assessment provided inaccurate examples to students (e.g., words containing schwa as examples of short vowel sounds) and were generally less able to appropriately respond to and correct student errors during explicit decoding instruction. In addition, post hoc exploratory analyses suggested differences in the specific types of explicit decoding instruction provided by teachers with higher versus lower Teacher Knowledge Assessment scores. Whereas teachers with lower scores tended to focus solely on teaching grapheme–phoneme correspondences and using these relations to sound out words, teachers with higher scores provided explicit instruction using a larger repertoire of decoding and word identification strategies (e.g., use of word families, analogies, and syllables).

When coupled with these observations, the Teacher Knowledge × Decoding Instruction interaction indicates that the quality of decoding instruction is the mechanism by which teacher knowledge influences student word-reading gains. The coding scheme of our study was not designed to index specific aspects of instructional quality, however. Although the consideration of only research-supported, explicit decoding instruction may be interpreted as a global assessment of instructional quality, future research to address this limitation is warranted.

Teacher Knowledge, Qualifications, and Education

Our sample of well-educated (100% with bachelor's degrees and 29% with master's degrees), highly experienced (M = 11.40 years) teachers displayed rather low levels of explicit knowledge concerning language/print structure and literacy concepts: Teachers averaged only 52% correct on the Teacher Knowledge Assessment. Other studies of teacher knowledge in this domain have found similar results (Bos et al., 2001; Cunningham et al., 2004; Mather et al., 2001; Moats, 1994; Moats & Foorman, 2003; Moats & Lyon, 1996; Troyer & Yopp, 1990). It appears that many teachers in the field lack the specialized content knowledge required to inform their classroom practices and provide first-grade students with effective explicit reading instruction.

Teacher qualifications may not provide an adequate index of the specialized knowledge that, as our results indicate, are associated with effective code-focused instruction. Consistent with our finding that teacher knowledge was unrelated to level of education, other evidence attempting to link teacher qualifications (e.g., credentials, years of education) to student literacy achievement has been equivocal at best (Connor et al., 2005; Goldhaber & Brewer, 1999, 2000). Although policymakers and professional organizations note that specialized knowledge is required for effective literacy instruction, this knowledge is often not reflected in state licensing exams or the professional standards of national credentialing agencies. For example, the International Reading Association's Professional Standards (International Reading Association, 2003), also utilized by the National Council for Accreditation of Teacher Education, require knowledge of the "psychological, sociological, and linguistic foundations of reading and writing," language development, and reading acquisition but fail to delineate the specific concepts and knowledge required in each of these categories. Teacher preparation programs may thus meet the broad goals of such professional standards while failing to provide preservice teachers with the specific content knowledge they need.

In our study, teachers' code-related knowledge was positively related to first-grade experience, but not overall teaching experience. Of course, the specialized knowledge tapped by the Teacher Knowledge Assessment is most relevant for first-grade teachers. All teachers involved in the ISI Project used highly scripted core curricula (i.e., Open Court or Reading Mastery; http://www.sraonline.com) that refer to important language and print concepts and corresponding instructional activities (e.g., introducing short vs. long vowel sounds and schwa, teaching phonological awareness and recognition of syllables). Familiarity with such curricula, daily use of these concepts in the classroom, and continued professional development relevant to first-grade teaching may have facilitated teachers' knowledge of language and print structure.

Yet even the use of such highly effective, scripted core curricula (Crowe & Connor, 2007) did not compensate for the generally less effective instruction provided by teachers who achieved lower scores on the Teacher Knowledge Assessment. We contend that these curricula cannot replace the expert teaching of highly knowledgeable teachers. Although core curricula may provide an important instructional base, teaching and learning within the classroom cannot be entirely prescribed or scripted. Teachers draw on their specialized knowledge of language and literacy when interacting with students in the moment. They adapt the core curricula lessons to meet individual students' needs. Based on our observations, this specialized knowledge may allow teachers to (a) correctly interpret and respond to student errors and questions, (b) choose appropriate examples for decoding and spelling instruction beyond those given in scripted lesson plans, and (c) allow for flexibility in core curricula use, when changes in intensity, scope, and/or sequence will better meet student's needs (Moats, 1999). Our results indicate that curricula cannot substitute for teacher expertise.

We interpret the findings of this study cautiously. As noted, the Teacher Knowledge Assessment was highly specific in terms of its scope and, although adapted from previously used measures (Bos et al., 2001; Mather et al., 2001; Moats, 1994; Moats & Foorman, 2003), this was the first time this specific task was administered. In addition, the Teacher Knowledge Assessment reflected teachers' code-focused, declarative knowledge and clearly does not reflect the entire specialized body of knowledge needed by teachers to effectively teach early reading. Knowledge of higher order concepts, including comprehension and metacognition, is also required, as is the procedural knowledge for utilizing declarative knowledge in practice (e.g., choosing appropriate instruction to address student errors). These additional types of knowledge may be particularly important for producing student comprehension gains. Further work to identify and validly assess teachers' content knowledge in other domains, and to link such knowledge to classroom practices and student achievement, is ongoing. Also, as an initial study of concurrent relations among teacher knowledge, classroom practice, and student outcomes, our coding of relevant instructional practices (i.e., explicit decoding) was intentionally simplistic. Future work in this area might consider more complex relations among these variables, particularly as informed by the Child × Instruction interaction literature (Connor, Jakobson, et al., 2009; Connor et al., 2007; Connor et al., 2004; Connor, Morrison, & Slominski, 2006).

An important strength of this study was its use of classroom observations. Examination of classroom practices at the level of the individual child was essential to our findings. Had we continued to treat the classroom as a "black box," we would have found no relation between teacher knowledge of language and early literacy concepts and student learning. The tendency for previous studies in this area to ignore classroom activities and the instruction provided to children, which varied within classrooms, may help to explain the inconsistent findings in the literature.

In sum, our results indicate that effective teachers have acquired a highly specialized body of knowledge about language and early literacy acquisition and enact this knowledge in the classroom. As policy initiatives continue to call for highly qualified teachers in every classroom, the exact definition of "highly qualified" should include the acquisition of such specialized knowledge as well as how to use this knowledge to promote student achievement.

ACKNOWLEDGMENTS

We wish to thank the ISI Project team members, especially the video coding group, including Chantel Huddleston, Stephanie Glasney, and Ummuhan Yesil-Dagli, for all their hard work. We appreciate the insight and advice of Chris Schatschneider, Stephanie Al Otaiba, Alysia Roehrig, and Phyllis Underwood. We also thank the school administrators, teachers, parents, and students without whom this research would not have been possible.

This work was supported, in part, by a Pre-Doctoral Interdisciplinary Training Grant R305B04074 from the Institute of Education Sciences. The ISI study was funded by grants R305H04013 and R305B070074, "Child by Instruction Interactions: Effects of Individualizing Instruction" from the U.S. Department of Education, Institute for Education Sciences and by grant R01HD48539 from the National Institute for Child Health and Human Development. The opinions expressed are ours and do not represent views of the funding agencies.

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