The Effects of Teacher Professional Development on Rural Students' Lexical Inferencing Skills

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Abstract

Rural students are at risk for vocabulary underdevelopment and often have less access to educational resources. The purpose of this investigation was to examine the effectiveness of an Internet-based Speech/Language Pathologist (SLP)-teacher consultation to support rural teachers' vocabulary instruction to improve their students' lexical inferencing skills. The investigators probed rural fourth-graders' lexical inferencing skills three times throughout a semester. The experimental group's teachers participated in SLP-teacher consultation, while the control group's teachers did not. Although both groups demonstrated increases in lexical inferencing skills, there were significant differences in the groups' error patterns. Clinical implications of these findings are discussed.

Keywords: vocabulary, consultation, progress monitoring, rural, adolescent

Reading comprehension is fundamental to the development of students' overall reading development and academic success (Alderson, 2000; Anderson & Freebody, 1981). Vocabulary knowledge has been specifically identified as a significant component of reading comprehension that is necessary for student success. On the one hand, students with adequate vocabulary skills are able to learn more words from extensive reading. On the other hand, the more words they add to their personal lexicons, the more advanced texts they can read and comprehend.

Biemiller and Slonim (2001) found that children who possess a breadth of vocabulary knowledge demonstrate greater academic achievement than students with limited vocabulary knowledge. The authors primarily attributed higher vocabulary knowledge to the students' ability to comprehend academic texts. Conversely, researchers also have found that students who have been identified as having reading comprehension difficulties have limited vocabulary knowledge (Biemiller & Boote, 2006; Rupley & Nichols, 2005). Addressing this relationship, numerous researchers have demonstrated that rigorous vocabulary instruction can result in improvements in reading comprehension (Boulware-Gooden, Carreker, Thornhill, & Joshi, 2007; Nelson & Stage, 2007). Given the importance of vocabulary knowledge in students' reading comprehension, the purpose of this study was to examine how a technology-based professional development (PD) program affected the lexical inferencing skills of students. In particular, this study examined the effects of a program in which a Speech/Language Pathologist (SLP) consulted with classroom teachers on scientifically-based vocabulary instruction on outcomes of students from rural, low socioeconomic backgrounds.

Vocabulary Knowledge, Socioeconomic Status, and Rural Children

The breadth of students' vocabulary knowledge is largely influenced by the number of words they encounter prior to starting school and differs based on socioeconomic status (SES). In their landmark study, Hart and Risley (1995) found that children from low SES families encounter approximately 10,000 words per year compared to children from high SES families, who encounter approximately 30,000 words per year. More recent studies measuring early vocabulary development also found SES-related differences, in which the difference in vocabulary size was dependent upon the difference in SES in the samples (Morrison, Bachman, & Connor, 2005; Pan, Rowe, Singer, & Snow, 2005; Rowe & Goldin-Meadow, 2009). Similarly, many children from low SES backgrounds demonstrate adequate progress with their reading skills through Grade Three but begin to show difficulties with their reading skills thereafter compared to children from high SES backgrounds (Chall, Jacobs, & Baldwin, 1990). Prior to Grade Three, the primary focus of reading instruction is on teaching children to decode; it is often not until the focus of reading instruction shifts to comprehension that students from low SES backgrounds demonstrate difficulties. Vocabulary knowledge expansion also has occurred more quickly for students in Grades 1-5 attending suburban schools than for those students in schools serving low-income children (White, Graves, & Slater, 1990). Students from low SES

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backgrounds, therefore, are more likely to disproportionately demonstrate late-emerging reading difficulties than same-aged peers from higher SES backgrounds (Kieffer, 2010).

In addition to the clear link between low SES and vocabulary development, research also has linked rurality and reading outcomes. Although rural school districts comprise nearly 57% of operating school districts in the United States (U.S. Department of Education, Institute of Education Sciences [IES], 2013), not many studies specifically have examined the academic performance of rural children compared to urban or suburban children. Nationwide, rural fourth graders performed as well as urban fourth graders but not as well as suburban fourth graders (U.S. Department of Education, IES, 2011). Furthermore, studies have suggested differences in academic outcomes among rural and urban children, with rural children underperforming in reading and math compared to urban or suburban children (Miller & Votruba-Drzal, 2013). Even when accounting for families' demographic and socioeconomic differences, rural children had fewer stimulating materials and experiences, while their parents held lower expectations for their academic attainment (Miller & Votruba-Drzal).

There are limited research studies that specifically have examined the association between school location (e.g., rural, urban, suburban) and vocabulary outcomes. Given that there is such a large population of children attending rural schools and that one-fifth of rural children live in poverty (Economic Research Service [ERS], 2012), it is likely that these children are at risk for vocabulary underdevelopment. That is, studies already have shown that children from low SES backgrounds are at risk for early vocabulary underdevelopment, which places these children at higher risk for poor reading comprehension. In addition, teachers in rural school districts have limited access to PD programs that would better equip them to foster vocabulary development in their students. Thus, educators and researchers should investigate how to integrate vocabulary-learning strategies into classroom instruction with this at-risk population to prevent academic failure.

Teacher Knowledge of Vocabulary Learning and Instruction

Although there are a number of scientifically based methods of teaching vocabulary to address vocabulary knowledge during reading instruction, many teachers report that they received little or no preservice training in these methods (Mather, Bos, & Babur, 2001), and investigations of school curricula have shown that there is little emphasis on the acquisition of vocabulary (Biemiller, 2001; Pearson, Hiebert, & Kamil, 2007). Methods of vocabulary instruction are based on knowledge of English language structure (e.g., morphology, syntax), but teacher training often does not involve adequate instruction about these aspects of English language knowledge (Vellutino, Scanlon, & Jaccard, 2003).

Schools of education may not be providing their preservice teachers with basic knowledge of literacy skills, including vocabulary instruction (Walsh, Glaser, & Wilcox, 2006). Other school professionals, such as SLPs, receive extensive training in language structure, the basic knowledge needed for literacy skills to develop, and assessment of literacy skills. Thus, collaboration and consultation between the SLP and classroom teacher could prove to be a powerful partnership in the identification and remediation of reading deficits.

Consultative Model of SLP Using Response to Intervention (RTI)

RTI and progress monitoring. RTI is a multi-tiered system of service delivery that allows for the frequent and early identification of students and promotes the use of high quality, evidence-based instruction. Progress monitoring typically uses curriculum-based measures (CBMs), such as the *Dynamic Indicators of Basic Early Literacy Skills* (DIBELS; Good & Kaminski, 2008), because they can be administered frequently and repeatedly over time (Deno, 1985) and have been shown to be good indicators of elementary students' overall academic performance to inform teacher's instruction (Fuchs & Fuchs, 2008).

While most CBMs are used for basic early literacy skills, mathematics, or writing, some researchers have developed content-specific CBMs, such as those for social studies (Espin, Shin, & Busch, 2005) and sciences (Johnson, Semmelroth, Allison, & Fritsch, 2013). A review of the research suggests that there are few, if any, known CBMs that specifically allow for progress monitoring of children's lexical inferencing skills; that is, few studies have examined to what information in a text a student is attending to infer the meanings of unknown vocabulary words. Knowledge of the strategies that students are and are not using can help inform instruction to improve these skills.

Indirect SLP services to support academic performance. With the shift towards RTI, there also has been a shift in the role of the SLP. While the school-based SLP once focused primarily on direct intervention of speech-language deficits of students with identified disorders, this focus now has shifted to a less direct approach that includes consultation with general and special education teachers to ensure that *all* students' language and literacy skills are developing (American Speech-Language-Hearing Association [ASHA], 2010). If teachers and SLPs hope to prevent student referrals for special education services, it is essential that they are aware of risk factors associated with academic failure and provide scientifically based instruction that targets areas of potential deficit.

The SLP's direct and indirect role in prevention and classroom-based service delivery has supported the implementation of phonological awareness instruction with very young children. Carson, Gillon, and Boustead (2013) implemented a consultative approach between SLPs and first grade teachers in which the teachers were instructed on how to implement a short but intensive whole-class teacher-directed phonological awareness program with positive

results. Another study used a collaborative model with an SLP and general education teacher to teach vocabulary to students with speech-language deficits in kindergarten through third grade (Throneburg, Calvert, Sturm, Paramboukas, & Paul, 2000). Results showed that employing this SLP-teacher collaborative model for teaching vocabulary was more effective than using a classroom-based model in which the SLP taught mini-lessons in the classroom, as well as more effective than using the traditional pull-out model for vocabulary intervention. Most important, using the collaborative model resulted in *all* students demonstrating positive effects on vocabulary development, not just the students with speech-language deficits. Others studies have illustrated the success of the SLP-teacher collaborative model in preschool settings (Peña & Quinn, 2003), inner city schools (Hadley, Simmerman, Long, & Luna, 2000), and suburban schools (Boyle, McCartney, Forbes, & O'Hare, 2007).

These studies illustrate how collaboration between SLPs and classroom teachers that target whole-classroom instruction and indirect-consultative service delivery can result in positive student gains. Application of such collaborative and consultative models means that more students are receiving the academic support they need and, ultimately, being prevented from being identified as needing special education services.

Although many schools are monitoring students' progress and differentiating instruction accordingly, vocabulary-learning skills, such as the ability to infer the meanings of unknown words, are often not specifically addressed. Reading fluency and reading comprehension skills frequently are examined, but noted difficulties could be related to a variety of language sub-skills, such as syntax or knowledge of discourse structures. Given that economically disadvantaged students in rural areas are at risk for vocabulary underdevelopment and that an impoverished vocabulary is linked to poor reading comprehension skills, effective vocabulary instruction methods and monitoring of vocabulary-learning progress are needed.

Indirect SLP service delivery using technology. Although many of these SLP-teacher collaborative models have been employed *within* the school setting, this model can be challenging in rural schools. That is, most models use a school-based SLP who consults with teachers in the classroom, allowing for the teachers and the SLP to meet frequently to discuss lesson plans, implement efficient progress monitoring, and evaluate the effectiveness of the instruction (Prelock, 2000; Giangreco, 2000; Peña & Quinn, 2003); however, rural SLPs are frequently itinerant and may be present only a few days of the week since they are traveling lengthy distances to service children in multiple schools and rarely have the time or sufficient resources to support teachers (Mashima & Doarn, 2008; Verdon, Wilson, Smith-Tamaray, & McAllister, 2011). As a result, the use of technology may be more effective for rural schoolteachers and SLPs to collaborate and ensure that students are receiving appropriate reading instruction through an indirect service delivery model.

The use of technology, such as telepractice and distance education, has been adopted among SLP professional associations in recognition of the importance of increasing service delivery. Research has shown the use of technology to support teachers' instruction, which in turn fosters acquisition of reading skills among their students. Students demonstrate significant gains in reading skills when instructed by teachers who are receiving technology-based literacy coaching in the form of web-conferencing with teachers and with students (Amendum, Vernon-Feagans, & Ginsberg, 2011; Vernon-Feagans, Kainz, Hedrick, Ginsberg, & Amendum, 2013). A study by Porche, Pallante, and Snow (2012) examined the effects on student reading skills following a teacher PD program delivered via a coaching model, whereby teachers received training and coaching in evidence-based literacy teaching strategies through a consultative model. Within this model, teachers received assistance from coaches and administrators, resulting in significant student gains in word recognition and reading comprehension skills. This emerging body of research demonstrates that both teachers and students can benefit from teacher PD via technology supports and online-based consultation; however, there have been few research studies examining the effectiveness of this model for the development of students' vocabulary-learning strategies.

Current Study

The purpose of this study was to examine how a technology-based teacher PD program impacted the lexical inferencing skills of fourth grade students in rural schools. Rather than providing teachers with a scripted program to follow, an important aspect of the PD program was to guide the teachers in making data-based decisions to inform their instructional practices. The researchers emphasized this critical component of RTI throughout the program. There were two specific research goals: (a) to examine whether rural teachers participating in a technology-based PD program demonstrated significant increases in their knowledge of RTI and vocabulary instruction strategies and (b) to examine the effectiveness of technology-based SLP consultation provided within the PD program with fourth-grade classroom teachers of rural, low SES students to improve their students' lexical inferencing abilities.

Method

Participants in Data Set 1. A total of 73 teachers (8 male, 65 female) completed a statewide technology-based PD program for K-12 teachers in a state in the Rocky Mountain region. Most participants (n = 69) were Caucasian or Native American (n = 4), with most reporting having a B.A. (n = 45), or M.A. (n = 28) degree. Participants reported teaching for 1-5 years (26%), 6-10 years (31%), 11-15 years (23)%, and 16+ years (19%). Furthermore, 49% of the participants reported working in an elementary school, while 1% reported working in a pre-school, 7% in a junior high/middle school, and 7% in a high school. Eighty-two percent taught at a school with fewer than 500 students, and

all of the participants worked in a town or city with a population of 100 to 5000 people.

Participants in Data Set 2. A limited number of teachers (n = 3) from this PD program agreed to participate further in this investigation by collecting data on their students' lexical inferencing. The investigators selected participants based on several inclusion criteria, with their students serving as the experimental group. First, participants had to teach fourth grade because previous studies have shown that rural students' reading comprehension skills begin to differ significantly from their suburban counterparts at Grade Four (i.e., IES, 2011). Second, teachers needed to agree to collect student data three times during the semester. Third, participants who had another fourth-grade teacher within their school or district, but who was not enrolled in the PD program, could participate. The study required a comparison group; thus, only participants with a matching teacher who did not participate in the PD were included.

Many of the teachers enrolled in the PD program were located in very rural areas, and were often the *only* teacher of that particular grade level in their school or district. Consequently, only 3 fourth-grade general education teachers enrolled in the PD program met the criteria for inclusion in the study, and their students (N = 36) comprised the experimental group. Students of 3 fourth grade teachers not participating in the PD program comprised the control group (N = 36). All teachers completed demographic information on their students: (a) students' ages, (b) gender, (c) race, and (d) eligibility for free or reduced price lunches. All schools were rural and were receiving Title I funding due to the SES backgrounds of the students, and 50% of the students in this sample were eligible for free or reduced price lunch.

Teachers de-identified and coded all student information before submitting it to the researchers. The investigators only included data from students without language or learning disabilities in this study to preserve the homogeneity of the sample. The university's Institutional Review Board approved all procedures prior to implementation. The demographic profiles of the participants are shown in Table 1.

As the investigators selected participants based on classroom placement and teacher, these were not randomly selected. The investigators performed chi-square tests of independence (with Yates Continuity Correction) to determine whether the participants differed with respect to socioeconomic status and gender. There were no significant differences between the two groups with respect socioeconomic status [X^2 (1, n = 72) = 1.34, p = .24, phi = .17] or gender [X^2 (1, n = 72) = .89, p = .35, phi = .14]. Fisher's Exact Probability Test revealed no significant differences with regard to race, p = 1.0. The investigators performed an independent samples t-test and observed no significant differences in participants' ages (in months) for the control (M = 122.03, SD = 5.23) and experimental groups (M = 121.14, SD =4.02; $t(70)$ = .81, p = .42).

Design and Procedure

Teacher PD program. The investigators provided a 17-week, statewide PD program offered through a university in the Rocky Mountain region to teachers in an online format. One investigator in the Department of Psychology was a licensed psychologist and nationally certified school psychologist and provided instruction focused on the principles of RTI and assessment. The other investigator in the Department of Communicative Sciences and Disorders was a licensed and certified SLP. She provided instruction focused on vocabulary-instruction strategies. The SLP consulted with the teachers at least twice per week during the 17-week program via web conferencing, online discussion forums, emails, and telephone conversations.

The following books were required reading material for the program: *Vocabulary Instruction: Research to Practice* (Kame'enui & Baumann, 2012), *Essential Readings on Vocabulary Instruction* (Graves, 2009), *Bringing Words to Life: Robust Vocabulary Instruction* (Beck, McKeown, & Kucan, 2002), and *Response to Intervention: Principles and Strategies for Effective Practice* (Brown-Chidsey & Steege, 2010). All of the vocabulary instruction strategies used in this study

Table 1

Demographic Profiles of Student Participants

	Age in Years				Gender		Race			
	n	*M*	*SD*	Range	M	F	Caucasian	Native American	Other	Free Reduced Lunch
Control	36	10.2	0.39	9.8-11.4	16	20	33	2	1	21
Experiment	36	10.1	0.39	9.11-11.2	21	15	33	0	3	15

are described in detail in these texts. The investigators assigned readings to the teachers on a weekly basis and provided them with detailed instructions and examples of how to implement vocabulary-learning strategies through video modules and web conferencing. They also instructed teachers to incorporate these strategies into their classroom teaching and required them to provide detailed descriptions regarding implementation, similar to annotated lesson plans, to receive credit for participation in the PD program.

Weeks 1 through 7 targeted RTI and early (preschool) vocabulary development. The investigators did not implement vocabulary-learning strategies in fourth-grade classes until Week 8. The strategies taught each week are illustrated in Table 2. For example, during one week of the PD program, teachers watched a 60-min lecture on selecting vocabulary words for instruction and then were required to select three Tier II words for instruction in their classrooms on Monday. In the assignment, teachers described the readings being used in the classroom, listed several Tier II words encountered in the text, explained why these words were considered Tier II words, and explained the process by which they selected the three that they did. The investigators examined each assignment for accuracy and contacted teachers via email if their vocabulary choices were questionable. After an online discussion of vocabulary selection methods, those teachers modified their selections and participated in an online discussion related to the implementation of the vocabulary selection strategy. The investigators read all of the discussion board entries to ensure that all teachers were implementing the strategy appropriately and provided feedback and suggestions to all participants. They scheduled each week of the PD program similarly.

Teacher knowledge of RTI and vocabulary instruction tests. Teachers in Data Set 1 (n = 73) completed a 50-item multiple-choice researcher-created test targeting the principles of RTI and vocabulary instruction strategies prior to this course and again following the course.

Lexical inferencing probes. Teachers in the program learned specific methods for teaching vocabulary-learning strategies to their students across the curriculum. Teachers in Data Set 2 (n = 6) administered vocabulary probes three times (January, March, and May) to obtain measures of the students' (n = 72) performance. That is, they assessed students' lexical inferencing skills prior to the introduction of vocabulary-learning strategies (Time 1/Baseline), 2 months following introduction of these strategies (Time 2), and 4 months following introduction of these strategies (Time 3). The investigators taught teachers how to examine data to differentiate student instruction and how to choose evidence-based interventions and strategies to address their students' needs.

The investigators administered probes to students in

Table 2

Professional Development Program Topics by Week

Week	*Professional Development Program Topic*	*Vocabulary-learning Strategy Taught*
1	Early Vocabulary Development	
2	Principles of Response to Intervention	-
3	Selecting Vocabulary Words for Instruction	-
4	Implementing Response to Intervention	-
5	Overview of Evidence-Based Interventions	-
6	Effective Instruction and Assessment	-
7	Addressing Learning and Behavior Difficulties	-
8	Selecting Individual Words for Instruction	Explicit Teaching of Tier II Words
9	Teaching Word-Learning Strategies	Identification of Affixes
10	Teaching Prefixes	Explicit Prefix Instruction
11	The Vocabulary-Spelling Connection	Derivational Morphological Patterns in Orthography: Attention to Meaning, Spelling, and Pronunciation
12	Contextual and Morphemic Analysis	Contextual and Morphemic Analysis
13	Fostering Word Consciousness	Attention to Word Order (Syntax)
14	Developing Word Consciousness	The VINE Intervention
15	Encouraging Incidental Word Learning	Classroom-based Word Games
16	Figurative Language	Identification of Idioms
17	Using Multimedia to Support Generative Vocabulary Learning	Student-created Vocabulary Journals

the experimental and control groups to assess their development of lexical inferencing. They administered three identical online vocabulary probes during the semester. They created the probes using SurveyMonkey electronic survey software (http://www.surveymonkey.com). They coded each response choice in the online probe according to accuracy prior to administration. Responses could be coded as (a) correct, (b) an error based on response syntactic fit, (c) an error based on semantic fit, or (d) an error based on grapho-phonemic similarity. The investigators calculated results automatically in SurveyMonkey. Each probe required students to infer the meanings of unknown words based on the linguistic context in which the word was encountered. They accomplished this by providing a grade-level reading passage in which two verbs, two nouns, and two adjectives were replaced with nonsense words. The students were to select the meaning of the word based on the linguistic context in which it occurred when presented with a field of four choices. One choice represented the intended (correct response) meaning (e.g., "bleam" = "to capture"). One choice was dissimilar in meaning but differed in no greater than two grapho-phonemic features with the nonsense word (e.g., "bleam" = "blame"). The investigators recorded these as grapho-phonemic errors. One choice was dissimilar in meaning but was within the same syntactic category as the intended meaning (e.g., "bleam" = "to release"). They recorded these as semantic errors. One choice was somewhat within the same semantic category but was not in the same syntactic category (e.g., "bleam" = "criminal"). They recorded these as syntactic errors.

The investigators conducted chi-square tests of independence to examine the relationship between the experimental and control groups' lexical inferencing skills based on these responses. They recorded responses as either correct (1) or incorrect (0) and conducted a mixed between-within subjects ANOVA to assess the effect of the vocabulary instruction on the groups' number of correct responses on the lexical inferencing probe across three time periods.

Program Fidelity

The investigators required teachers of the experimental group to describe how they implemented the vocabulary instruction strategies taught in the course each week in an online forum. The teachers posted to a weekly forum at least three times to receive full credit in the course. The investigators monitored forum entries for accurate application. In instances when a forum entry was posted in which it was unclear as to whether the teacher was implementing the strategy correctly, the investigators requested a clarification. In instances when a teacher's forum entry indicated that the teacher may have been implementing a strategy incorrectly, the investigators provided a concrete example of how to implement the strategy and required that teacher to report on her "repaired" implementation of that strategy. All teachers correctly implemented the strategies taught in the course by the end of each week.

Results

Teacher knowledge of RTI and vocabulary instruction. The investigator conducted a paired-samples *t*-test to evaluate the impact of the PD program on teachers' pre- and post-test scores on the RTI and Vocabulary Instruction test. There was a statistically significant increase in test scores from pre-test (M= 24.2, SD = 6.45) to post-test (M= 36.3, SD = 4.72), t (71) = -12.78, $p < .0001$ (two-tailed). The eta squared statistic (.70) indicated a large effect size.

Lexical inferencing. The investigators compared students' lexical inferencing skills at Time 1/Baseline, Time 2, and Time 3. A one-way ANOVA revealed no significant Group X Time interaction with regard to the number of correct responses produced by the control and experimental groups, Wilks' Lambda = .94, F (2, 69) = 2.03, p = .139, partial eta squared = .056, nor was there a substantial main effect for time, Wilks' Lambda = .97, F (2, 69) = 1.02, p = .154, partial eta squared = .029. When they compared the number of grapho-phonemic errors across the three times, they observed no significant effect for time, Wilks' Lambda = .99, F (2, 69) = .03, p = .972, partial eta squared = .001, but they found a significant Group X Time interaction, Wilks' Lambda = .91, F (2, 69) = 3.24, p = .045.

To further examine the lexical inferencing skills of both groups across time, the investigators compared how their responses were distributed across type (i.e., correct response, semantic error, syntactic error, or grapho-phonemic error). They conducted chi-square tests of independence to determine whether the response patterns of students who were and were not receiving instruction in vocabulary-learning strategies followed a similar progression. That is, in addition to calculating the proportion of correct responses, they wanted to examine changes in error responses to determine incremental improvements over time. The relation between Time 1 responses and Group was not significant, x^2 (3, n = 432) = .102, p = .216, Cramer's V = .102, indicating that both groups responded similarly before the vocabulary-learning strategies were introduced. The relation between Time 2 responses and Group was significant, x^2 (3, n = 432) = 10.4, p = .015, Cramer's V = .155, as was the relation between Time 3 and Group, x^2 (3, n = 432) = 13.27, p = .004, Cramer's V = .175, indicating a small significant effect size.

Figures 1 through 4 show the percentage of each group's correct responses, incorrect responses based on semantic similarity (syntactic error), incorrect responses based on syntactic fit (semantic error), and incorrect responses based on grapho-phonemic similarity on each of the three probes. Both groups exhibited similarity in response patterns in that both increased the number of correct responses and decreased the number of incorrect responses based on semantic and syntactic fit over time. The investigators observed group differences in the number of incorrect responses based on grapho-phonemic similarity. The experimental group exhibited a decrease in the number of errors over time while the control group exhibited an increase in the number of errors.

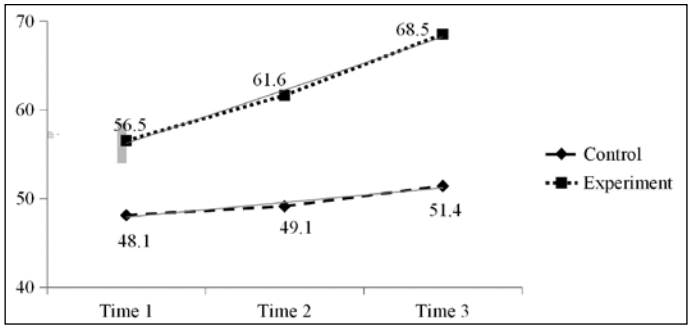

Figure 1. Percentage of correct responses across probes at Times 1, 2, and 3.

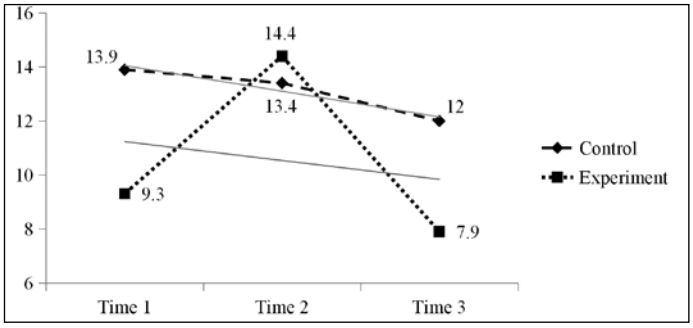

Figure 2. Percentage of errors based on semantic similarity across probes at Times 1, 2, and 3.

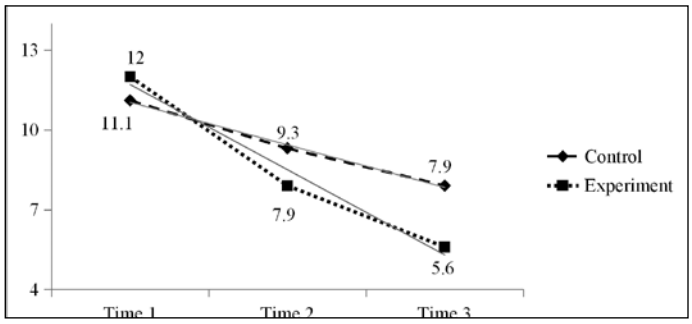

Figure 3. Percentage of errors based on syntactic fit across probes at Times 1, 2, and 3.

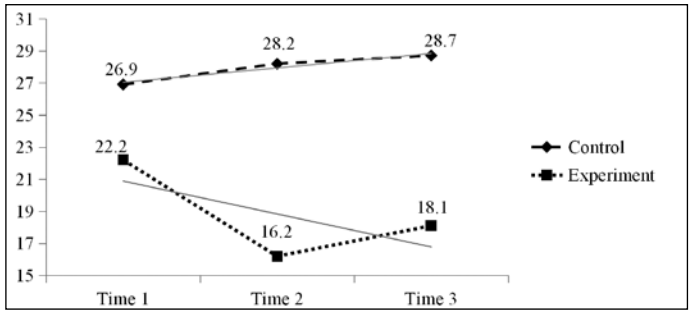

Figure 4. Percentage of errors based on grapho-phonemic similarity across probes at Times 1, 2, and 3.

Discussion

The purpose of this investigation was to examine how a technology-based PD program in which an SLP consulted with classroom teachers on scientifically based vocabulary instruction affects the lexical inferencing skills of students from rural and low socioeconomic backgrounds. Rural schools often lack resources, including full-time SLPs, to sufficiently and effectively meet students' vocabulary development. SLPs who provide services to rural teachers and students often work in schools that are miles apart, and teachers have limited access to professional development compared to their counterparts in urban areas (Mollenkopf, 2009). As a result, this investigation contributes to the existing research by highlighting how technology-based PD programs using weekly coaching and training can benefit students' vocabulary development.

The first goal in this investigation was to determine whether teachers would demonstrate significant improvement in their knowledge of RTI principles and vocabulary teaching strategies after participating in a technology-based PD program. Results of the pre- and post-test scores on this measure indicated that was indeed the case; teachers performed significantly better at post-test. Many teachers reported that, prior to participating in this PD program, they had not learned of using contextual analysis as a method for determining the meaning of an unknown word in a text. They explained that this was an extremely useful strategy, while also being very easy to implement. For example, one teacher reported that, when reading *Charlotte's Web* (White, 1952), a student encountered the word *spinneret*. She explained that, after instruction in the contextual analysis strategy, the student examined the sentence in which the word was encountered and stated that a spinneret must be the part of the spider's body that she holds her silk in before she uses it to spin her web. Prior to introducing this strategy, the teacher explained that this student frequently guessed the meanings of unknown words based on that word's grapho-phonemic similarity to a known word, such as guessing *spinneret* must mean *spinach*.

The second goal in this investigation was to examine changes in lexical inferencing skills based on contextual information in rural, low SES fourth-graders whose teachers did and did not participate in the online PD program. Results of the study showed that fourth graders in the experimental group demonstrated noted improvements in their lexical inferencing skills, particularly related to decreases in their grapho-phonemic similarity errors. Interestingly, while there were no statistically significant group differences in the number of correct responses on each of the probes, analysis of the incorrect responses revealed students in the experimental group demonstrated steady *decreases* in errors based on grapho-phonemic similarity, while the control group demonstrated *increases* in errors of this type. That is, while both groups demonstrated increases in the number of correct responses across time and decreases in the number of incorrect responses based on semantic and syntactic fit across time, there were contrasts in how these fourth graders recognized differences in grapho-phonemic features with a nonsense word. Fourth graders in the experimental group modified their lexical inferencing strategies over time, with the measure of lexical inferencing being sensitive to those changes.

Selecting responses based on grapho-phonemic similarity to the nonsense word was the least effective lexical inferencing strategy. Fourth grade students using this strategy did not appear sensitive to the linguistic context in which the word occurred and did not base their choices on the semantic or syntactic fit of that word in the sentence. As students in the experimental group made fewer errors based on grapho-phonemic similarity across time, this suggests that their sensitivity to linguistic context increased with instruction in vocabulary-learning strategies. This finding also supports the theory that vocabulary is learned incrementally over time (Stahl, 2003). Progress monitoring tools that are designed to examine students' error patterns may be more sensitive to students' responsiveness to instruction than progress monitoring tools that are only used to report the number of correct responses.

In the present investigation, teachers in the experimental group were quick to adopt instructional strategies that increased their students' syntactic and semantic awareness in determining the meanings of unfamiliar words. As the investigators were monitoring the weekly discussion forums for treatment fidelity, they noted that many teachers reported that the instructional sequence for increasing students' ability to derive word meaning from context (Goerss, Beck, & McKeown, 1999) was particularly successful. These teachers explained that, by simply paraphrasing the reading passages before their students read them and emphasizing the overall *meaning* of the context, their students were better able to identify the relationship between the context and the unknown word. When students were more sensitive to the role the unknown word played within the context of the reading passage, the better able they were to infer the correct meaning of that unknown word. The teachers in the experimental group also reported that this strategy was easily applied across content areas and required minimal preparation. They indicated that they used this strategy when providing instruction in math, science, and social studies, as well as English Language Arts. They also indicated that the periodic lexical inferencing probes provided them with the feedback needed to make data-based decisions based on their students' responses to vocabulary instruction strategies.

Limitations and Future Directions

Several limitations of this study warrant discussion. First, the sample size was relatively small and homogenous. Most of the participants and all of the teachers in Data Set 2 were Caucasian, which is representative of the ethnic composition in this region of the country. The classroom sizes in these rural areas in the northwest were small (approximately 10 students); so 3 fourth-grade classes were combined to form each group (N = 36). Future research studies should examine whether a consultative model would be effective with a larger, more heterogeneous sample of students and teachers.

Second, the investigators measured treatment fidelity through self-report from and communication with the teachers. Direct observation of the teachers' implementation of vocabulary-learning strategy instruction was not feasible since participating schools were as far as 500 miles away. Teachers instead reported how they implemented each of the vocabulary-learning strategies into their lessons. Direct observation and modeling may have resulted in a more rapid adoption of the vocabulary-learning strategies and would have been more reliable evidence of accuracy. Indeed, other researchers have utilized web cameras and other technology to facilitate consultation and collaboration (Vernon-Feagans et al., 2013). The investigators also had considered providing the teachers with written "scripts" to follow in their instruction, but this would not have provided accurate information about the external validity of the consultative model. This provision of scripts also would have been counterproductive to the teachers evaluating their students' error patterns on the probes and adapting their instruction to meet their specific needs. Although the investigators recognized the need for control in the study, they elected to give the teachers the freedom to choose the strategies that they felt would best benefit their students since this was more representative of the consultative model. Future studies might involve the use of video recordings or written transcripts of classroom instruction to more accurately assess treatment fidelity.

Third, this study would have been more robust had the investigators directly measured participating students' reading skills. If the experimental and control groups were found to have commensurate reading scores at baseline, and the experimental group were to outperform the control group after the instructional period, this would have provided greater evidence of the impact of this study. Since all students participating in this investigation were being periodically assessed using either *Dynamic Indicators of Basic Early Literacy Skills* (DIBELS; Dynamic Measurement Group, 2008; Good & Kaminski, 1996) or *Measures of Academic Progress* (MAP; Northwest Evaluation Association, 2012), the investigators attempted to obtain the oral reading fluency scores of both groups of students. These attempts were unsuccessful for a few reasons. The investigators relied on the teachers to report their students' oral reading fluency scores when reporting other demographic data. Some teachers found interpreting the DIBELS and MAP scores confusing and reported unreliable scores. For example, one student's oral reading fluency score was reported to be 488 words correct per min (WCPM). The investigators repeatedly attempted to clarify which score should be reported and demonstrated how that score could be found on each of the progress monitoring tools' score sheets. Even after multiple attempts to report the oral reading fluency scores of their students, some teacher's reported scores appeared very unlikely (e.g., over 400 WCPM), so the investigators abandoned their efforts at obtaining oral reading fluency scores.

Overall, this study contributes to the growing body of literature on the effects of indirect SLP service models on student outcomes. In fact, the efficacy of indirect service

delivery should continue to be examined in the field of school-based speech-language pathology. Implementation science can be a useful methodology to better understand how evidence-based vocabulary strategies can be implemented in schools. Understanding the processes by which evidence-based practices are being implemented in school systems, the key elements that make up those practices, as well the specific stakeholders involved, are key elements in ensuring the effective implementation of evidence-based practices (Fixsen, Naoom, Blase, Friedman, & Wallace, 2005). Given the lack of resources in rural schools, SLPs are becoming increasingly important in collaborating and consulting with teachers to implement effective vocabulary strategies and to monitor student progress to ensure those strategies are effective for all students. Future studies should examine how SLPs can play an important role in moving the science of vocabulary instruction to practice.

Clinical Implications

Preliminary findings of this study may help inform school-based SLPs in selecting service delivery models. In this study, the investigators consulted with classroom teachers and provided them with information about the principles of RTI and evidence-based vocabulary instruction strategies. The researchers did not, however, provide direct instruction or intervention to their students, who were the subjects of this investigation. Yet, participants in the experimental group demonstrated significant improvements in their use of lexical inferencing strategies when their teachers incorporated vocabulary-learning strategies into their lessons. These findings lend support to the consultative model of SLP service delivery, which may be more a viable alternative to the more traditional "pull-out" model of intervention for itinerant SLPs who must travel long distances to schools in remote areas, much like the schools involved in this study. This model also appears to be efficient in providing whole-classroom instruction, particularly with groups of students who are at risk for vocabulary underdevelopment. The students who participated in this study had not been identified as having language disorders but were isolated in rural northwest communities characterized by economic disadvantage, and the experimental group demonstrated more sophisticated lexical inferencing strategies than did the control group by the end of the semester.

Findings from this study also may be useful in selecting or designing tools for monitoring students' incremental progress in vocabulary learning. Vocabulary knowledge develops incrementally with repeated exposures to words; so many static assessment tools are not sensitive to small, incremental changes in students' vocabulary knowledge. By analyzing the types of errors a student exhibits on a lexical inferencing probe, such as the one used in this study, SLPs can identify the strategies that a student is using to determine the meanings of unknown words and then adapt interventions accordingly. SLPs also can consult with the students' classroom teachers to ensure that whole-classroom instruction involves vocabulary-learning strategies.

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