The Impact of a Reading-Focused Integrated Learning System on Phonological Awareness in Kindergarten

Jerrell C. Cassady
Ball State University

Lawrence L. Smith
Ball State University

Children with and without access to a reading-focused Integrated Learning System (ILS) in their daily reading instruction were compared at three points (beginning, middle, end) through their kindergarten year on phonological awareness and concepts about print. The results demonstrated no significant differences in learning print concepts. However, repeated measures analysis of variance demonstrated that the children with access to the ILS in their classroom significantly outperformed the comparison group at the second and third testing sessions on phonological awareness, despite no group differences at baseline. The results are interpreted to support the assertion that ILSs can improve the emergent literacy process for young children, provided they are embedded in a sound reading curriculum that is directed by a committed and active reading teacher. Finally, differences between the present study and related investigations are discussed.

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In a joint position statement, the International Reading Association (IRA) and the National Association for the Education of Young Children (NAEYC, 1998) summarized reading as a complex set of tasks that is promoted by the constant interplay between development and learning, typically progressing in a continuous fashion through the primary grades. The statement also reported that teaching children to read in kindergarten was generally most successful with systematic and structured instructional programs that promoted acquisition of phonological awareness, the alphabetic principle, and vocabulary, as well as contextualized reading activities. Finally, the joint position statement asserted the importance of having flexible and individualized instruction available for all students to be

successful, with ready access to print materials, computer programs, or experienced tutors to support that development through regular and continual practice.

Delivering individualized instruction in the kindergarten year is particularly challenging given the wide range of skills and abilities demonstrated by children; Riley (1996) estimated a potential range of 5 developmental years (i.e., 3-8). Despite the widespread acknowledgement that students need personalized attention in order to learn basic phonological and orthographic processing skills that lead through an interactive nature to success in independent reading (Wagner, Torgesen, & Rashotte, 1994), the implementation of such varied instructional strategies in one classroom proves challenging at best, and improbable for many teachers. To enable teachers to engage in individualized reading instruction, we have found two primary requirements must be in place (Walker, Smith, & Cassady, 2003). First, teachers must develop an attitude toward reading that demonstrates their fundamental belief that all children can read. Second, teachers must have adequate support, in the forms of professional development, sufficient access to resources, and a culture within the school that encourages risk-taking. In an attempt to foster and develop teacher efficacy for reading, the Intentional Reading Project (IRP) was initiated. As outlined in more detail later, the IRP was a concerted effort to: (a) develop the level of access to supportive literacy instruction materials, (b) direct and concentrated teacher professional development (using coaching and one-on-one tutoring models), and (c) establish strong links among elementary reading teachers and reading instruction experts connected through a University Professional Development School network. The simple overarching goal was communicated to teachers as an attempt to help them become more intentional in their efforts to teach reading to all children, with particular focus on children who struggle with early reading skills. This investigation documents one particular aspect of that project: the impact of a structured, reading-based Integrated Learning System (ILS) on phonological awareness skill acquisition for children in kindergarten.

Phonological Awareness in Early Reading

Although phonological awareness is commonly viewed as an important emergent literacy skill, there is no universally accepted operational definition. Scarborough and Brady (2002) offer a glossary for the "phon" terms, citing the common problems in the literature of research teams using different terms for the same processes, or perhaps worse, using the same terms for different processes. Our operational definition for phonological awareness has been consistent with their glossary: phonological awareness is the awareness of constituent sounds of words and the ability to detect and eventually manipulate auditory units that do not necessarily

hold syntactic meaning (Goswami, 2000; Harris & Hodges, 1995; Snow, Burns, & Griffin, 1998; Sodoro, Allinder, & Rankin-Erickson, 2002). The largest confusion in the literature seems to be distinguishing phonological and phonemic awareness. Essentially, phonemic awareness is a subset of the broader construct of phonological awareness. Phonological awareness also encompasses syllable, onset-rime, and body-coda units (Snow et al., 1998) and involves conscious awareness of the smallest distinguishable auditory units in words (Harris & Hodges, 1995). Various models of phonological awareness skill acquisition have been offered (e.g., Adams, 1990; Yopp, 1988), and there is general agreement that children first detect then manipulate units, and that awareness progresses from larger units (i.e., syllables) to smaller units (phonemes). Consistent with the IRA-NAEYC position statement (NAEYC, 1998), our empirical analyses of multiple subtasks in phonological awareness have demonstrated remarkable continuity in acquiring skills for tasks that increase in complexity (Cassady et al., 2003).

Early success in phonological and phonemic awareness has repeatedly been demonstrated to predict subsequent reading ability (Calfee, Lindamood, & Lindamood, 1973; Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh, & Shanahan, 2001; Mann, 1993; Metsala, 1999; Wagner, 1988). Not surprisingly, there have been repeated findings of success for reading intervention programs that have focused on phonological or phonemic awareness, particularly when those programs recognize the interactive nature of phonology and orthography in early reading development (Byrne & Fielding-Barnsley, 1995; Cunningham, 1990; Ehri et al., 2001). However, the data repeatedly demonstrate that no program in particular is the solution to meeting the diverse needs of children who have various levels of skill in phonological awareness and early literacy (NAEYC, 1998; Torgesen, 2000). This has generally led to a conclusion that it is the implementation of the program or the teacher that makes the difference. Again, our position is that optimal reading instruction is possible when teachers who believe they can teach children to read have the necessary knowledge and resources to enact their skills.

Educational Technology and Reading Instruction

One emerging source of support for teachers is the continual development of increasingly more sophisticated computer-based instructional tools. Effective educational technology implementation is typically enabled in classrooms where the technology tools are used to promote and support a constructivist model of learning (Davis & Shade, 1999). In particular, the use of educational technology is proposed to be most effective when the materials are fully integrated and consistent with the curriculum and provide ongoing scaffolding for each learner (Yelland,

1999), serving as the "bridge" between teacher-led instruction and self-guided learning (Ferguson, 2001). Such Integrated Learning Systems (ILS) move beyond standard computer-assisted instruction programs that function largely as remedial instruction disconnected from the curriculum or game-like reward activities for students completing their work (Davis & Shade, 1999; Underwood, 2000).

The research on educational technology and literacy development has not been compelling to date, with mixed results on short- and long-term academic gains and concerns about the cost-effectiveness of the systems (Blok, Oostdam, Otter, & Overmaat, 2002). However, we have abstracted two generalizations regarding research on technology and literacy: (a) Gains in research on computer-based tools are typically short-lived due to the limitations in scope and content in most computer packages, and (b) methodological design issues have hindered the examination of the impact of ILSs in realistic instructional settings.

Regarding limited content, reviews of programs with literacy-related activities conclude that performance gains observed for the technology-supported treatments were only maintained as long as enriching content was available. That is, treatment group members showed early growth exceeding controls, but the difference was overcome when instruction in the classroom included the target objectives and the software program exhausted its set of activities (Mathes, Torgesen, & Allor, 2001).

Two methodological designs have been popular in pursuing questions regarding the effectiveness of an ILS, both of which lead to limitations in generalizing results to classroom settings. A sizable portion of research has been conducted in a method that pits "computer against teacher," by comparing outcomes for technology-only and teacher-only instructional settings. These studies typically demonstrate that the technology provides positive gains in phonological awareness but does not lead to long-term benefits that exceed the standard pedagogical processes (Mitchell & Fox, 2001; Underwood, 2000). The inherent problem in such a research design is that the underlying question focuses on whether the children can learn the content in the absence of the teacher. We find this to be a moot question and an undesirable method of school-based research.

The second methodological approach examines technology that is offered to one group while a comparison group receives no literacy instruction (using after-school programs or preschool populations). The conclusions from this research demonstrate that the technology group outperforms the control group on literacy measures (Liao, 1999); however, withholding all instruction is neither ethical nor viable in schools. These research programs essentially indicate that ILSs can support literacy learning, but the design issues have restricted the ability to address the level

of benefit that is available when the ILS is used to support the teaching practices of qualified teachers of reading. Thus, our investigation has attempted to overcome this common problem created by the logistics of school-based research.

Method

Overview

The present investigation is an empirical study of the impact of an Integrated Learning System (ILS) added to the existing reading curricula of kindergarten classrooms. We compared the level of growth in both phonological awareness and concepts about print for children in kindergarten, with the primary pedagogical difference between the treatment and comparison groups resting on the full integration of the ILS as a supportive literacy development program for all students.

The data for this study were drawn from a larger study tracking the success of a professional development initiative implemented in the treatment and comparison schools. The schools engaged in this research were in the second year of the Intentional Reading Project (IRP), a programmatic attempt to help teachers in the primary grades become more intentional about supporting the acquisition of reading skills for all students. Due to their involvement in the project, the teachers at the two schools were engaged in ongoing professional development activities and received various resources to support their delivery of effective literacy instruction. These services were provided by a team of university researchers and literacy experts who joined with the project schools in the IRP. Both schools were offered equivalent services and received nearly identical access to both professional development and resources. However, the delayed implementation of one of the school's ILSs created an unexpected opportunity to empirically test the differences in the kindergarten reading curricula. This opportunity helped to overcome several of the logistical barriers faced in previous research with computer applications. Because both the control and treatment groups were involved in an intensive professional development program, access to the ILS became the primary instructional difference between the two groups.

The curricula at both schools were determined by state standards for kindergarten classrooms. In particular, the classrooms targeted phonological awareness (phoneme counting, phoneme deletion, phoneme substitution, blending CVC words, providing rhymes upon request, and isolating the first and last sounds in one-syllable words). Although teachers had control over day-to-day curriculum planning, teachers in both schools reported following the same general order of presentation. Specifically, the first half of the academic year was dominated by examining blending, segmenting, rhyme, and phoneme isolation skills; the second half of the

year built upon these skills and began to establish the alphabetic principle, word identification, and promoting automaticity in these early literacy skills. Consistency in curricula in the two schools located in different districts was also facilitated by the presence of the university-based professional development team.

The dominant literacy instruction practice employed at both schools involved use of an adopted reading series, embedded within a larger literacy instruction framework that incorporated both skills-based instruction (e.g., phonics instruction) and whole-language elements (e.g., word walls or inventive writing). The reading curriculum experts working with each classroom indicated that all classrooms were following a "modified four-blocks" curriculum (Cunningham, Hall, & Defee, 1991). Structured classroom observations using the CIERA (Taylor & Pearson, 2000) observation scheme confirmed that the instructional environments were similar across the two schools. The CIERA observation scheme demonstrated that across multiple observations (no fewer than two observations per classroom), teachers in both schools were seen to have a "Major Focus" on reading activities, with activities converging on phonics skills (letter-sound, letter-by-letter, and onset-rime), phonemic awareness, letter identification, word recognition strategies, and sight words (primarily through the use of word walls). During the observations teachers at both schools used primarily large and small group instruction to deliver a mixture of didactic and student-centered instructional methods.

Teachers' self-reports using DeFord's (1985) Theoretical Orientation to Reading Profile also revealed no differences in attitudes toward the strategies and activities appropriate for instruction at the kindergarten level, with all teachers falling into the "skills perspective" toward reading instruction on the scale.

The primary instructional difference between the two schools during the 2001-2002 academic year was based on the implementation of a computer-based literacy program (as an addition to the standard literacy curricula) in one of the kindergarten classrooms. As part of their involvement in the IRP, the schools were given some financial support to offset the expense of installing the computers and software necessary to implement the ILS chosen by the teachers and administration. The university professional development team hosted a technology fair at which five vendors demonstrated their literacy programs. Following the technology fair, school leaders selected the program that was most consistent with their approach to reading instruction or compatible with their school technology plan.

Participants

Kindergarten students at two schools participated in the IRP. The two schools were located roughly 50 miles from each other and differed in the populations served.

Treatment Group. "School A" is in a rural community on the outskirts of a moderately sized midwestern city. The school serves a population of approximately 325 students across grades K through 6 each year. The student population is predominately White: 1% Black, 2% multiracial, and 97% White. Eleven percent of the students receive federal assistance to pay for lunches (7% free, 4% reduced). Data from the state-mandated standardized testing program in the third grade for the fall of 2001 revealed that 90% of the students passed the math standard and 74% passed the language arts standard for the state. For this study, complete data from 26 children were available across the entire kindergarten year. The sample included 15 females and 11 males, with an average age at the start of kindergarten of 68.84 months ($SD = 3.4$). All children were instructed by the same teacher and were Fully English Proficient at the beginning of their kindergarten year.

School A (hereafter ILS group) chose to use the Waterford Early Reading Program (WERP) and was effective in infusing the program into their curricular activities during the first quarter of the 2001-2002 school year (see details in following section) and maintaining that use throughout the course of the instructional year. According to the publisher:

> The Waterford Early Reading Program's unique computer-based instruction adapts to an individual user's learning pace, regardless of primary language or pre-literacy exposure. The three-level curriculum integrates classroom-based assessments, instructional activities, and aligned materials for systematic instruction in the five reading essentials as defined by the *National Reading Panel Report*: Phonemics • Phonics • Vocabulary • Fluency • Comprehension. Each level provides a full year of daily instructional activities, as well as a library of take-home materials for each child to extend the learning process. Just 15 minutes each day (30 minutes for Levels 2 and 3) of independent, self-paced instruction encourage students with immediate feedback (Pearson Digital, 2003).

The teachers and administration at the school selected WERP because they believed the program best met their students' instructional needs, mapped well onto their primary grade reading curriculum, and made strong connections between home and school through the integrated "take-home" reading series that was aligned with the computer-based applications. The implementation of WERP entailed the installation of four classroom computers that were used in a function similar to stations, such that each child worked with the assigned WERP activity every day. Children were scheduled to work approximately 20 minutes per day on the program, with variations arising due to typical school interruptions (e.g., absences, school delays for weather). Children met the 20-minute expectation;

extra available time allowed at least one day per week where the student completed two sessions. All the children completed the Level 1 activities, which targeted phonemic awareness, print concepts, and basic exposure to literature through stories (Pearson Digital, 2003).

By year's end, most children were engaged in Level 2 activities that focused on specific phonological awareness skills such as blending, learning to detect sight words, and early comprehension strategies. The WERP activities were purposefully chosen by the teacher or university consultants to coincide with the child's learning progress in the standard reading curriculum and did not follow a predetermined order of activities. Using the ILS's user monitoring program, we determined that from October to May of the kindergarten year, each student completed roughly 30 hours of programmed instruction (M = 30:38:05).

As the teachers specifically selected the WERP system due to the compatibility with the existing literacy curriculum, little effort was required to align the classroom instruction with the ILS. To tailor learning activities for each child, the teacher selected the computer-based modules for each student that matched current classroom goals. This process required teacher training and technical support in the early stages, which was addressed in this study by assigning one graduate student with training on operating WERP and expertise in early literacy to provide part-time technical support to the school. The WERP classification system for each learning activity used language common to the state standards for reading and literacy, which facilitated alignment to the reading curriculum. In addition to selecting upcoming modules, teachers monitored progress through students' user accounts in order to determine skills needing further teacher support.

In addition to the computer-based program, teachers in the ILS group were involved in a system of reading-focused professional development and in-classroom support. The professional development process involved periodic (roughly once a month) group training on research-supported literacy instruction practices, with follow-up small group and individual coaching on grade-level reading instruction. One university faculty member and one graduate research assistant, both with expertise in literacy and reading, visited the school no less than once a week to provide this support.

Comparison Group. "School B," located in a suburban community near a large midwestern city, serves approximately 650 students per year in grades K through 5. School B serves a diverse population: 4% Asian, 28% Black, 9% Hispanic, and 53% White. Thirty-nine percent of the students receive assistance for the school lunch program (29% free, 10% reduced). Similar to the ILS group, data from the

state-mandated standardized testing program in the third grade for the fall of 2001 revealed that 84% of the students passed the state standard for math, and 73% met the standard for language arts. Complete data were available from 62 children who were instructed by three teachers in the kindergarten classrooms. There were 24 females and 32 males with a mean age of 66.17 months at the start of kindergarten ($SD = 3.71$). All children included in this study were identified as Fully English Proficient at the beginning of the kindergarten year.

Teachers at School B (hereafter "no-ILS") selected the PLATO/Wasatch early reading programs after reviewing several options. Initially, the selection team preferred the Waterford Early Reading Program (WERP), but the school had already invested considerable resources in computer hardware that was not compatible with WERP. The teachers noted that the PLATO system enabled a full K-6 treatment, which was not possible with the WERP.

The no-ILS school had five networked computers capable of running the PLATO materials in each classroom, with an additional 30-station lab that was available for scheduling. Although the materials were installed at the same time as the ILS group, the PLATO program was not implemented by the kindergarten teachers in the no-ILS school due to a series of technical difficulties. In particular, each student logging on to use the program was required to navigate through eight decision screens in order to load the appropriate module. This process took up to 15 minutes (before reaching the instructional content) for each child and required the presence of an adult. In this study, the adult was either the teacher or the assigned graduate student with detailed training in using the PLATO materials. Teachers found this to be a poor use of instructional time and adult guidance in the classroom. Furthermore, the Internet-based program overwhelmed the school server repeatedly, causing "crashes" that further exacerbated the experience for the teachers.

Given these barriers, the program was never a part of the daily curriculum, with the exception of four students in the no-ILS school. These four students used PLATO regularly due to the direct intervention of a graduate research assistant from the university team. These four students demonstrated statistically significant greater growth on the dependent variables as compared to their classmates. However, given the small sample size and the differential level of direct support offered to those four students given their frequent interaction with a reading curriculum expert, they have been removed from the present study.

Although the no-ILS group did not implement its chosen integrated learning system, the teachers were still involved in professional development provided through the IRP. As with the ILS group, one university faculty member and one graduate

research assistant with expertise in literacy and reading instruction also visited the school at least once a week to help teachers promote reading in the primary grades. These two experts met regularly (typically once a week) with their counterparts in the ILS group to coordinate the professional development programs with the project director. The graduate research assistant at each school had received extensive training on the use of the ILS chosen by their respective schools, thereby enabling them to provide technical support, demonstrate the process of aligning curricula with the computer learning activities, and show both teachers and students how to access the appropriate learning modules.

Measures

To address the kindergarten students' progress in emergent literacy skills, we administered one measure of phonological awareness and one measure of awareness of print concepts at three points in the school year. These two measures were chosen because of the primary focus of both schools on these state-mandated priority standards for reading (Indiana Department of Education, 2003) and the consensus in the literature that these two skill areas are the strongest predictors of future reading performance.

Phonological Awareness. Following the lead of established phonological and phonemic awareness skills development theories (Adams, 1990; Stahl & Murray, 1994; Yopp, 1988), the newly created Phonological Awareness Test (PAT) was developed to directly assess young children's phonological awareness skills. The PAT is an individually administered oral evaluation given to assess a child's skill with 13 discrete phonological awareness tasks. Each of the 13 subtests consists of an example item that the administrator models for the child, two practice items that allow for corrective feedback when necessary, and five scored items. The administrator provides verbal instructions for all subtests prior to modeling the example item (see Table 1 for representative items and abridged verbal instructions). Because the first five subtests involve presentation of multiple words for auditory discrimination tasks, there is a potential confound with working memory capacity (Yopp, 1988). Therefore, following the convention of phonological awareness testing, representative images were presented in subtests that involved students detecting phonological similarities or differences among a list of words.

The PAT differs from other measures of phonological awareness by disentangling commonly confounded phonological awareness tasks by controlling for the effects of both linguistic complexity (e.g., onset-rime vs. phoneme; see Stahl & Murray, 1994) and skill difficulty (e.g., blending vs. segmenting; Adams, 1990; Yopp, 1988). Furthermore, the subtests of the PAT explore differences in performance for detecting and manipulating phonemes based on three positions in CVC words: beginning,

Table 1. Phonological Awareness Test: Sample Items and Directions

Subtest	Basic instructions	Sample item(s)
Rhyme recognition	Rhymes are words that sound the same at the end…Tell me if these words rhyme.	**ape-knee; dip-hip**
Rhyme application	Tell me a word that rhymes with:	**Star** (accept any word or nonsense word that rhymes)
Oddity tasks: Beginning sounds	Listen to the names of these pictures. Tell me which one has a different *beginning* sound.	**nest, soap, nails**
Oddity tasks: Ending sounds	Listen to the names of these pictures. Tell me which one has a different *ending* sound.	**bell, web, crib**
Oddity tasks: Middle sounds	Listen to the names of these pictures. Tell me which one has a different *middle* sound.	**beak, cone, heel**
Blending onset-rimes	I will say the first sound and then the rest of the word to make a whole word…Tell me the word I have when I put these sounds together.	**/w/ eek**
Segmenting onset-rimes	Separate the word by saying the first sound and then the rest of the word:	Separate the word **coat** by saying the first sound and then the rest of the word.
Blending phonemes	I'm going to say a word slowly, and then I'll say it fast, **/s/ /u/ /n/, sun.**	I'll say a word slowly. You say it fast **/s/ /a/ /ve/.**
Segmenting phonemes	Say each sound you hear in the word.	**job**
Phoneme deletion	Listen to the word _____. Take away the **first** sound, what is left?	Listen to the word **book**. Take away the **/b/** sound, what is left?
Phoneme substitution: Beginning sounds	If I say the word **man** and change the first sound to **/p/**, the new word is **pan**.	Change the first sound in **cat** to **/h/**. What is the new word?
Phoneme substitution: Ending sounds	If I say the word **rat** and change the last sound to **/g/**, the new word is **rag**.	Say the word **can**, change the last sound to **/p/**, what's the new word?
Phoneme substitution: Middle sounds	If I say the word **pan**, change the middle sound to **/i/**, the new word is **pin**.	Say the word **cat**, change the middle sound to **/o/**, what's the new word?

middle, and end. Our research has demonstrated that the PAT is reliable through both internal consistency estimates and factor analyses. Concurrent validity was also approximated through comparisons of PAT performance with standardized reading achievement measures (CTBS *Terra Nova*) and structured teacher ratings of reading skills (Cassady et al., 2003).

Print Concepts. The students also completed the Concepts About Print test, using Clay's *Stones* (1980) and *Follow Me Moon* (2000). The Concepts About Print (CAP) measure is commonly conducted in Reading Recovery programs to assess students' levels of awareness for how spoken language is represented in print format. A child demonstrating high levels of print awareness does so through tasks such as locating the front of the book, identifying selected letters or key words in the text, detecting errors in the positioning of text or pictures on the page, and showing proficiency with rules of punctuation and capitalization (Caldwell, 2002).

Data Collection. To track growth in phonological awareness and print concept awareness, all kindergarten students in the two schools completed the PAT and CAP in individual testing sessions at three points in the academic year. Due to the length of the PAT (average completion time was approximately 20 minutes), all kindergarten students completed the materials in two testing sessions that were no more than five days apart. The first administration was in the fall directly before the ILSs were installed (October), the second was in January (to capture the differences in growth between the two schools over the first half of the year), and the third was completed at the end of the school year (May). All testing occurred during school hours in locations near the child's classroom (e.g., teacher's office, study area near room). The children were familiar with the test administrators, who were the reading instruction experts working in their schools.

Results

Two 2 (group) by 3 (time) repeated measures analyses of variance (ANOVA), one for the CAP and one for the PAT, were performed to test differences over time between the two groups (see Table 2 for means and standard deviations). The ANOVA examining performance on the CAP demonstrated a significant and strong main effect for the repeated factor of time ($F[2, 85] = 142.67$, $p < .001$, $\eta^2 = .77$). This effect merely shows that all children in both schools demonstrated growth in CAP scores, as would be expected in any kindergarten program driven by the state standards. The interaction effect was also statistically significant, ($F[2, 85] = 3.05$, $p < .05$, $\eta^2 = .07$). This result shows that there was a difference in the rate of growth across the three times when comparing the scores from the two groups, but the strength of the effect was weak. Finally, the between-groups analysis, which

compares overall differences between the two groups, without consideration for changes over time revealed a statistically significant difference as well ($F[1, 86] = 7.61$, $p < .007$, $\eta^2 = .08$). As with the interaction, the effect size was weak. This result reflects the finding that children in the ILS group started out with higher CAP scores and maintained that edge throughout the year. Thus, the results do not provide strong support for the notion that the ILS promoted children's understanding of basic print concepts, particularly in the measured domain of book knowledge. The lack of strong impact of technology on concepts about print was not overly surprising, as the ILS is not designed specifically to promote these skills in the kindergarten year. During kindergarten, the computer program focus is geared more toward the alphabetic principle and phonemic awareness.

Table 2. Performance Measure Means at the Three Repeated Administration Periods

	October *M* (SD)	January *M* (SD)	May *M* (SD)
		Concepts About Print	
ILS group ($n = 26$)	11.69 (3.62)	15.12 (2.81)	17.46 (2.76)
No-ILS ($n = 62$)	8.52 (4.74)	13.05 (3.95)	16.24 (3.50)
		Phonological Awareness Test	
ILS group ($n = 26$)	17.04 (10.08)	35.85 (12.51)	46.38 (11.24)
No-ILS ($n = 62$)	17.14 (11.53)	27.71 (15.57)	37.18 (15.58)

Examination of the growth in phonological awareness revealed a different pattern. The repeated factor was once again significant, showing overall growth when looking at both groups combined ($F[2, 85] = 196.90$, $p < .001$, $\eta^2 = .82$). As before, the overall between-groups effect was statistically significant but weak ($F[1, 86] = 4.03$, $p < .05$, $\eta^2 = .05$). The weak level of this effect is due to the fact that the two schools started out at equivalent performance levels in the fall of kindergarten, and only differed in performance at the midway and end-of-year assessment. The trend of greatest interest in this design is the interaction effect, where the rate of growth on the performance measure is compared between the two groups rather than the overall group mean differences averaged across all times. In this sample, the interaction effect between time and school was both statistically significant and meaningful, demonstrating a different pattern of phonological awareness acquisition over time for the two schools ($F[2, 85] = 8.07$, $p < .001$, $\eta^2 = .16$). Figure 1 illustrates the pattern of growth, where the ILS group enjoyed faster acquisition of phonological awareness than students in the no-ILS group during the fall of kindergarten, then maintained its advantage through the end of the school year.

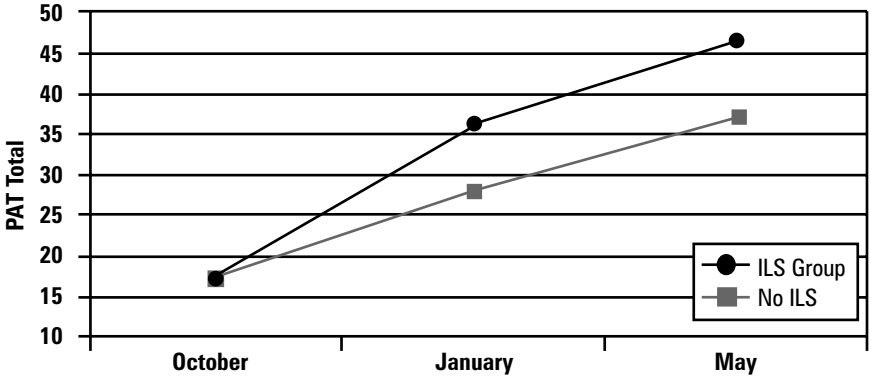

Figure 1. Kindergarten students' phonological awareness growth with and with out access to ILS.

Discussion

Results support the notion that implementing an ILS into the kindergarten curriculum can have a measurable and meaningful effect on student growth and progress in phonological awareness, a primary precursor to eventual reading success (Ehri et al., 2001). Our pedagogical orientation has been that technology resources can empower teachers to improve their literacy instruction by having a larger variety of instructional tools at their disposal. We believe that a key feature to the successes of the ILS noted in this study was the high level of pre-existing coordination between the ILS group's existing emergent literacy curriculum and the goals of the ILS modules targeting kindergarten. Furthermore, teachers reported that this particular ILS (Waterford) was easy to learn and implement, which enabled them to tailor the instructional activities for each child.

A recent article examining the same ILS concluded that the Waterford program had no significant impact on kindergarten and first grade students' emergent reading skill development (Paterson, Henry, O'Quin, Ceprano, & Blue, 2003). Our results do not align with their findings, but examination of the implementation and assessment practices from the two studies may explain the variance in our conclusions. First, the teachers in the Paterson et al. (2003) study were reported to have low levels of effort or interest in actively integrating the Waterford materials into the existing literacy instruction program, opting to place full faith in the ILS to determine the pace, sequence, and progress of delivering the computer-based content. In our study, teachers fully integrated the materials into the existing curriculum, attempting to make the program a daily extension of teacher-delivered instruction. Ongoing professional development supported teachers'

skill development for identifying the connections between the ILS activities and the in-class reading curricula.

A second difference between the studies was the nature of the treatment and comparison groups. In our study, a direct test of adding the ILS to a standard reading instruction setting was made possible by the unexpected delay in implementation of the ILS for the comparison group. Otherwise, the instructional support provided to the two groups was equivalent. In addition, all children were afforded access to the materials and followed through the course of the project. In the Paterson et al. (2003) study, only those classrooms with the highest rates of students at risk for failure were provided with the treatment. This potential inequity in samples was only partially controlled in the selection process, which could be accounted for through statistical techniques given a design such as ours that examines growth in performance over time. However, the Paterson et al. (2003) study employed a "post-test only" design, so no reliable information regarding beginning levels of reading skill could not be controlled in the analyses.

However, we concur with the primary conclusion in the Paterson et al. (2003) study, that teacher behavior and pedagogy are primary determinants of reading performance. Our data demonstrate that ILSs can promote gains in phonological awareness during the kindergarten year when they are implemented in conjunction with an existing reading curriculum. Furthermore, we conjecture that the gains observed in our study would not likely be realized in the absence of adequate professional development or support on reading instruction.

As with all school-based research, threats to validity need to be addressed. First, the difference in populations served by the no-ILS and ILS schools was a factor that could not be controlled and was a threat to validity. However, in our analyses, no effects were found in comparisons across race, gender, or "free/reduced" lunch status. Furthermore, the initial scores on the primary dependent variable (phonological awareness) demonstrated that on that measure of emergent literacy, the two groups were at equivalent starting points. The differences in this study could also be tied to teacher effects. However, analyses of both teacher attitude and behavior toward reading instruction revealed no detectable difference among the teachers on these variables. Furthermore, the professional development programs at the two schools were essentially equal, with the exception of the ILS group receiving more direct training on how to administer the ILS activities in that year of the project.

Through our work with teachers and students using ILSs in kindergarten classroom, we have concluded that there is a positive impact on student phonological

awareness skill development. Given our experiences, and the data available for this study, we have developed a set of suggestions for incorporating ILSs into a standard literacy instruction setting. First, the content and materials that accompany the ILS must be aligned with the classroom curriculum. This requires work on the part of the teacher to consciously tie all phases of the literacy instruction program together. In the absence of this coordinated effort, teachers are likely to find that the ILS becomes an ancillary object that holds little educational value. Second, teachers need to have adequate training and support for using the technology materials. In the absence of training and technical support, teachers are likely to avoid heavy use of the ILS, particularly when presented with even small technical difficulties. Third, teachers need adequate training and support for reading instruction. Our observation of the use of these materials has demonstrated that one of the most critical features underlying successful implementation is the ability of the reading teacher to actively adjust her or his curriculum to make the ILS an integrated part of the overall reading instruction process. This has been most successful in conditions where the teacher has a good base of expertise in effective reading instruction, because the teacher is more able to see the connections among the variety of instructional tools at his or her disposal. Fourth, when teachers make the decision to integrate an ILS into the classroom, they should be attentive to issues of classroom management. In classrooms where the students know when and how to access their learning materials on the computer without repeated or extended teacher assistance, the ILS can be in more continuous operation, maximizing the overall level of independent use by the students. This is greatly facilitated by features of ILSs that allow teachers to specify the order of student use (and what activities each student will do), so that when each student finishes her or his session, the program alerts the exiting child to get the next student on the list. This automatized classroom procedure frees the teacher to concentrate on other educational activities.

References

Adams, M. J. (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.

Blok, H., Oostdam, R., Otter, M. E., & Overmaat, M. (2002). Computer-assisted instruction in support of beginning reading instruction: A review. *Review of Educational Research, 72,* 101-130.

Byrne, B., & Fielding-Barnsley, R. (1995). Evaluation of a program to teach phonemic awareness to young children: A 2- and 3-year follow-up and a new preschool trial. *Journal of Educational Psychology, 87,* 488-503.

Caldwell, J. S. (2002). *Reading assessment: A primer for teachers and tutors.* New York: Guilford Press.

Calfee, R. C., Lindamood, P., & Lindamood, C. (1973). Acoustic-phonetic skills and reading: Kindergarten through twelfth grade. *Journal of Educational Psychology, 64,* 293-298.

Cassady, J. C., Smith, L. L., Bottomley, D., Popplewell, S., Walker, C., Bauserman, K., Jordan, F., & Edmunds, K. (2003). *Assessing the acquisition of phonological awareness skills: Simultaneously examining the influences of task difficulty and linguistic complexity.* Unpublished manuscript.

Clay, M. (2000). *Follow me moon.* Portsmouth, NH: Heinemann.

Clay, M. (1980). *Stones.* Portsmouth, NH: Heinemann.

Cunningham, A. E. (1990). Explicit versus implicit instruction in phonemic awareness. *Journal of Experimental Child Psychology, 50,* 429-444.

Cunningham, P. M., Hall, D. P. & Defee, M, (1991). Nonability grouped, multilevel instruction: A year in a first grade classroom. *Reading Teacher, 44,* 566-571.

Davis, B. C., & Shade, D. D. (1999). Integrating technology in the early childhood classroom: The case of literacy learning. *Information Technology in Childhood Education, 1999*(1), 221-254.

DeFord, D. (1985). Validating the construct of theoretical orientation in reading instruction. *Reading Research Quarterly, 20,* 336-367.

Ehri, L., Nunes, S., Willows, D. Schuster, B. B., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly, 36,* 250-87.

Ferguson, D. (2001). Technology in a constructivist classroom. *Information Technology in Childhood Education Annual, 2001*(1), 45-55.

Goswami, U. (2000). Phonological and lexical processes. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of Reading Research* (Vol. III; pp. 251-268). Mahwah, NJ: Erlbaum.

Harris, T. L., & Hodges, R. E. (1995). *The literacy dictionary: The vocabulary of reading and writing.* Newark, DE: International Reading Association.

Indiana Department of Education (2003). *Indiana's academic standards: Teacher edition, English/Language Arts.* Indianapolis, IN: Indiana Department of Education.

Liao, Y. C. (1999). Effects of hypermedia on students' achievement: A meta-analysis. *Journal of Multimedia and Hypermedia, 8,* 255-277.

Mann, V. (1993). Phoneme awareness and future reading ability. *Journal of Learning Disabilities, 26,* 259-269.

Mathes, P. G., Torgesen, J. K., & Allor, J. H. (2001). The effects of peer-assisted literacy strategies for first-grade readers with and without additional computer-assisted instruction in phonological awareness. *American Educational Research Journal, 38,* 371-410.

Metsala, J. L. (1999). Young children's phonological awareness and nonword repetition as a function of vocabulary development. *Journal of Educational Psychology, 91,* 3-19.

Mitchell, M. J., & Fox, B. J. (2001). The effects of computer software for developing phonological awareness in low-progress readers. *Reading Research and Instruction, 40,* 315-332.

National Association of Education for Young Children (1998). Learning to read and write: Developmentally appropriate practices for young children. *Young Children, 53*(4), 30-46.

Paterson, W. A., Henry, J. J., O'Quin, K., Ceprano, M. A., & Blue, E. V. (2003). Investigating the effectiveness of an integrated learning system on early emergent readers. *Reading Research Quarterly, 38,* 172-207.

Pearson Digital (2003). About the Waterford Early Reading Program. Retrieved April 6, 2003, from http://www.pearsondigital.com/EE_1a_WERP/EE_1a1_WERP_PO.htm

Riley, J. (1996). *The teaching of reading.* London: Paul Chapman.

Scarborough, H. S., & Brady, S. A. (2002). Toward a common terminology for talking about speech and reading: A glossary of the "phon" words and some related terms. *Journal of Literacy Research, 34,* 299-336.

Snow, C. E., Burns, M. S., & Griffin, P. (Eds.). (1998). *Preventing reading difficulties in young children.* Washington, DC: National Academy Press.

Sodoro, J., Allinder, R. M., & Rankin-Erickson, J. L. (2002). Assessment of phonological awareness: Review of methods and tools. *Educational Psychology Review, 14,* 223-260.

Stahl, S. A., & Murray, B. A. (1994). Defining phonological awareness and its relationship to early reading. *Journal of Educational Psychology, 86,* 221-234.

Taylor, B. M., & Pearson, P. D. (2000). *The CIERA school change classroom observation scheme.* Minneapolis, MN: Center for the Improvement of Early Reading Achievement.

Torgesen, J. K. (2000). Individual differences in response to early interventions in reading: The lingering problem of treatment resisters. *Learning Disabilities Research & Practice, 15*(1), 55-64.

Underwood, J. D. M. (2000). A comparison of two types of computer support for reading development. *Journal of Research in Reading, 23*(2), 136-148.

Wagner, R. K. (1988). Causal relations between the development of phonological processing abilities and the acquisition of reading skills: A meta-analysis. *Merrill-Palmer Quarterly, 34,* 261-279.

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: New evidence of bi-directional causality from a latent variable longitudinal study. *Developmental Psychology, 30,* 73-87.

Walker, C. A., Smith, L. L., & Cassady, J. C. (2003). *Intentional approaches to reading instruction: Working with teachers in a long-term professional development project.* Unpublished manuscript.

Yelland, N. (1999). Reconceptualising schooling with technology for the 21st century: Images and reflections. *Information Technology in Childhood Education Annual, 1999*(1), 39-59.

Yopp, H. K. (1988). The validity and reliability of phonemic awareness tests. *Reading Research Quarterly, 23,* 159-177.