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Evaluation of a Computer-based Program On the Reading Performance Of First Grade Students With Potential for Reading Failure

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ABSTRACT: This study investigated the effects of a software-based early reading program on the early reading abilities of first grade students with disabilities or who had potential for reading failure. Balanced reading instruction was the instructional approach because of increasing evidence that effective reading instruction must strike a balance between opportunities to read and write connected text and instruction in word identification (including phonics/decoding instruction). The study included students from inclusive classrooms in six different states and was conducted during the 1998-1999 school year. Students in the experimental group evidenced a wide range of disabilities, but shared a common and identifiable problem with early literacy knowledge and skills. A group of typically developing students served as the criterion group for the study. The results indicated that all the within-subjects main effects were statistically significant for all measures except for two subtests. A perspective on the significant gains of the students in the experimental group and the need for additional research of longer duration is discussed.

The development of literacy skills in kindergarten and early elementary-age children has become an unquestioned national priority in the education of students with and without disabilities. Coupled with the increasing importance of competency-based and proficiency-based testing in the United States, the development and evaluation of early literacy instructional programs, designed to meet the needs of all learners, is becoming increasingly important.

Historically, many children with disabilities have not profited from efforts in general education to ensure that all children learn to read in the first grade (Allington & McGill-Franzen, 1992; Johnston & Allington, 1991). The norm has been for children with disabilities to receive remedial reading instruction from special education professionals and paraprofessionals (Cunningham & Allington, 1999). In addition, reading specialists provide remedial services to children without disabilities who are considered at risk for school failure because of reading and writing difficulties. Children are often referred for special education placement when they do not make expected progress in the remedial programs provided by reading specialists.

One consequence of the dual system of services is that children who have the most difficult time learning to read and write (e.g., children with disabilities and/or at-risk of reading failure) receive reading instruction from teachers who may be inadequately prepared to meet their literacy learning needs. The type of reading instruction that children with disabilities often receive is narrow in focus and lacking in contextualized direct instruction and other types of instructional approaches which research suggests struggling readers need in order to learn to read and write (Allington, 1994).

The research regarding literacy instruction for children with disabilities is replete with studies of word identification instructional interventions, and it is generally accepted that children with disabilities can learn to read words taught in isolation (Barudin & Hourcade, 1990; Conners, 1992; McCormick & Becker, 1996; Rudolph, 1990). There is also evidence that young children with disabilities can develop concepts about print, knowledge of book structures, and other skills relevant to emergent literacy that are required for success with early literacy instruction (Katims, 1991; Kliewer, 1998). The question still remains, however, whether there are more efficient means by which young children with disabilities can develop the range of skills and understandings that children without disabilities

acquire in early literacy instruction which would allow them to make the transition from emergent to conventional literacy with greater ease and fluency.

Given that the controversy concerning the best way to teach literacy in general education is ongoing and cyclical, it is expected that the debate and controversy will also continue among special educators for years to come. However, there are several important lessons that have emerged from the general education and special education debates. First, one learns from the general education debate that there is no single approach that will meet the needs of all children (Adams, 1990; Wharton-McDonald et al., 1997). Secondly, general educators have begun to systematically integrate direct instruction in word reading (e.g., including phonics) with meaningful opportunities to read and write connected text (Cunningham & Allington, 1999; Pressley, 1998; Weaver, 1998). Finally, special educators can learn from their own history and ensure that direct phonics instruction is contextualized in such a manner that it increases the chances of children with disabilities generalizing what they are taught across tasks and texts. (Pressley, 1998; Weaver, 1998).

In the development of the prototype reading instruction program used in this study, the authors and the commercial developers of the software, IntelliTools Reading (hereafter referred to as "the program") (IntelliTools, in press) attempted to systematically merge many of the components believed most critical in allowing children to make the transition from emergent to conventional literacy. The software-based approach is designed for children who have developed basic emergent literacy skills such as: (a) print has meaning (not necessarily letter name knowledge); (b) knowledge of conventions of books (e.g., pages turn right to left and words carry the meaning); and (c) language comprehension sufficient to understand very easy children's books. The scope of the prototype program used in this study represented approximately 40% of a projected final commercial product.

Critical Reading Instruction Components

One essential component of early reading is word identification (Cunningham, 1993; LaBerge & Samuels, 1985; Perfetti, 1985; Stanovich, 1991), which for purposes of this application, describes words that children read in isolation (i.e., without the benefit of pictures or context for support). Word identification includes two subprocesses, decoding and automatic word identification. In decoding, the reader applies knowledge of letter-sound correspondence, spelling patterns, and other phonics strategies to read individual words. In automatic word identification, the reader recognizes the words without conscious attention to the phonemic characteristics. Often words that are identified automatically do not have regular phonemic characteristics. However, words that were once decoded in word identification can become words that are read automatically, given enough successful practice reading the word within connected text.

Two sub-components of decoding in early reading instruction are onsets and rimes (Wylie & Durrell, 1970). With respect to single-syllable words, onsets are consonants and consonant clusters found at the beginning of a single syllable. The onset is most clearly defined as all of the consonants that are found before the first vowel in a single syllable. Not all single syllables have an onset (e.g., the word all). Rimes are clusters of letters that begin with the first vowel and continue to the end of a single-syllable. While not all single-syllables have an onset, they all have a rime. Early readers can be taught to combine their knowledge of onsets and rimes to read words that are not read automatically.

Instruction in word identification is only one part of an effective early literacy program. While there are people who would argue that a phonics-only approach is the best way to teach children to read, there is growing acceptance of the concept that effective instruction must strike a balance between opportunities to read and write connected text and instruction in word identification, including phonics/decoding instruction (Allington, 1997; Cunningham & Allington, 1999; Pressley, 1998). This combination of: (a) instruction in phonics, (b) instruction in automatic word identification, (c) instruction in reading connected text, and (d) opportunities to independently read self-selected texts comprise balanced reading instruction as the term is used here. It is important to note that this definition of balanced reading instruction includes approximately equivalent amounts of time spent addressing each of the four primary components, and, to the greatest extent possible, a seamless integration of each of the components.

Overview of the Study

This study investigated the impact of a computer-based balanced reading instruction approach on the early reading abilities of first-grade students identified by their teachers as having great difficulty learning to read, and/or identified with a physical and/or educational disability by their school system. The program was developed as the result of initial and continuous feedback from reading experts in both general and special education. A study using students from inclusive classrooms in six states was conducted during the 1998-1999 school year to assess the impact of the program. The students from the experimental group evidenced a wide range of disabilities, but shared a common and identifiable concern from their teachers regarding their early literacy knowledge and skills.

Another group of more typically developing students in the same classrooms as some of the experimental students served as the criterion group for the study. Specifically, this study investigated the effects of the Intellitools Reading program on: (a) onset-rime word decoding skills, (b) phonemic awareness skills, (c) sight word recognition skills, and (d) developmental writing and spelling skills of this sample of first-grade students.

Method

The processes for developing, implementing, and evaluating the effectiveness of the program are described in five subsections: (a) the participants, (b) the instructional program components, (c) the procedures used in the implementation, (d) the development of the instrument, and (e) the data gathering and analysis techniques.

Participants

The students participating in this study were all first graders from schools that were using, or interested in using, products from the IntelliTools company other than IntelliTools Reading. In order to be considered for inclusion in the study, the schools were required to have access to a Macintosh computer equipped with a CD-ROM, color monitor, and 32 megabytes of memory. After obtaining parental consent, students identified by their teachers and principals as either having potential for reading failure or having identified physical and/or educational disabilities (e.g., physical, orthopedic, speech-language, and/or learning disabilities) were placed in the experimental group (n=35). Students in the experimental group met one or more of the following criteria: (a) diagnosed need for special education service, (b) below 80% on Word Identification Pre-primer scores on the pretest, (c) repeated first grade, and (d) teacher nomination. The remaining students in two of the participating classrooms were placed in the criterion group (n=25). Over the course of the intervention, five students left their schools, two in the criterion group and three in the experimental group. The final sample consisted of 55 students.

The students in the experimental group received their regular reading instruction with their class along with the 16-week, software-based instruction as a supplement. Students in the criterion group received their regular reading instruction only. There were no attempts to control for the type of instruction provided in the general education classroom. None of the sites had a specific early literacy instructional program, but each had some mix of phonics instruction, reading of children's literature, and writing. The regular classroom reading instruction ranged in duration from 60 to 120 minutes per day with fluctuations within and across sites. In each site there was some overlap between the intervention instruction and the typical classroom instruction, but there was no evidence that it complemented, supported or otherwise expanded upon the reading instruction in any one setting more than another. Controlling for these issues was not part of this investigation.

Development of IntelliTools Reading

IntelliTools Reading was developed as the prototype of a full-scale early reading and writing program being developed by IntelliTools, Inc. The prototype was developed using the authoring tool, IntelliPics, (IntelliTools, 1994), and a beta version of a new talking word processing program, IntelliTalk II, (IntelliTools, 2000). The final Intellitools Reading product will span an entire year of instruction. The prototype tested in this study included four units, or 16 weeks, of instructional materials.

Each of the four units in the prototype shared a common structure in terms of the types of instructional activities and materials. The structure was based upon a balanced approach to reading instruction and included: (a) reading of connected text for comprehension; (b) word study and reading of connected text for the purpose of building word

identification skills and decoding skills; and (c) structured writing activities. Each unit was built around an anchor storybook authored specifically for the program (see Figure 1 for an example of a page from an anchor story).

Figure 1. Example of a page from an anchor story
(The illustrations that appeared in the original paper were taken from the prototype software. They have been replaced here to reflect the published product.)

The four anchor stories had characteristics consistent with early literacy programs that emphasize predictable text with repeated lines and pictures that relate directly to the text. The sight words, onsets, and rimes used in the anchor stories served as the basis for the word study instruction provided within each unit.

In addition to the anchor story, each unit had little books that provided opportunities to practice new sight words and new decoding skills in books with a great degree of vocabulary control and decodability. The purpose of inclusion of these little books was twofold: (a) build automaticity and fluency with sight words and (b) build skills in application of newly acquired onset-rime decoding skills. Figure 2 provides an example of a page from a little book.

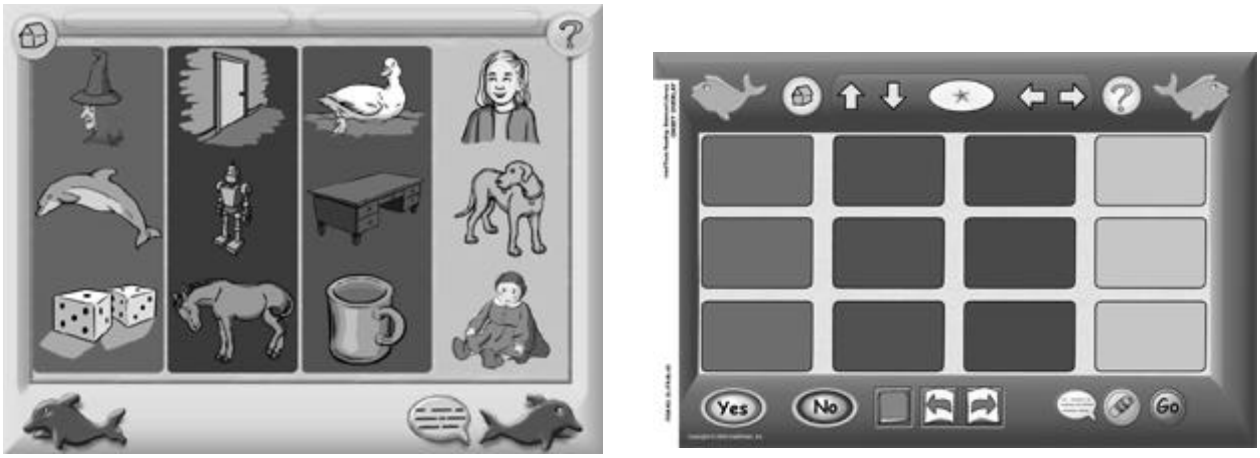
Figure 2. Example of a page from a little book

These reading opportunities were coupled with word study activities that systematically taught children to decode words using an onset-rime strategy. Onsets and rimes were introduced by a song and a book. For example, when the onset /d/ was introduced, children heard the short song with these lyrics, "dolphins diving hear the sound, /d/ /d/ /d/." Then, the children read a short, computer-based book about dark, dancing, and dirty, dolphins diving. After listening to and reviewing the songs and books, the children explored words and items that began with the onset or ended with the rime. Finally, the children completed a number of activities that required them to listen to two words

spoken aloud while looking at pictures representing those words and making judgments about whether they had a common onset or rime. For example, children saw a picture of a wig and a pig and were asked, "Do wig and pig have the same ending? Wig, Pig."

Other word study activities required children to combine and recombine onsets and rimes to make real words. When a child was unsuccessful at making the word requested, instructional feedback was provided that told the child which word they did make and provided them with an opportunity and support in making the requested word. Figure 3 provides an example of the onscreen graphics and the IntelliKeys overlay that children used to respond to the question.

Figure 3. Example of an on-screen graphic and the IntelliKeys overlay



The final component allowed children to compose simple sentences using pre-selected whole words and some onsets and rimes. These words, onsets and rimes were presented on an IntelliKeys keyboard overlay. Children used an overlay with a prototype of the talking word processing program, IntelliTalk II (IntelliTools, 2000) to compose text that was comprised of words and pictures.

A consistent set of balanced-reading instructional activities was repeated several times during the four-week unit, and opportunities to review and repeat activities were built into the cycle. The adults working with the children were provided with a schedule that indicated the order in which activities were to be completed.

The adults introduced and worked with two or three books and/or activities in each 15 minute session. The general sequence of activities within each unit was as follows:

1. Reading Activity: Read anchor story
2. Reading Activity: Complete a guided reading lesson focused on comprehension of the anchor story
3. Word Study Activity: Onsets
4. Writing Activity: Sentence composition
5. Word Study Activity: Rimes
6. Reading Activity: Little books
7. Reading Activity: Trade books related to the theme of the anchor story

The program was designed to include 15 minutes of instruction supported and directed by an adult and 15 minutes of extended practice during a single lesson, or approximately 30-minutes per day. In general, the program was used for 4 days each week for a total of 16 weeks, giving the experimental students a minimum of 32 hours of exposure to the program during the course of the study. While there was a prescribed sequence to the instructional materials included with each unit, the adults who worked with students had the opportunity to adjust the schedule as they deemed appropriate. Furthermore, they had to be thoughtful about using materials that supplemented the prototype program (e.g. word cards and cards with onsets, rimes, and mnemonic pictures) and using other means to reinforce or otherwise support the students in learning the skills and gaining the understandings that were a part of each unit.

With only one exception, the program was implemented by instructional aides or graduate interns who did not have teacher certification or specialized training in reading instruction. At two sites, all of the instruction was provided by paraprofessionals. All of the adults worked with the children in small groups (usually 2 or 3 children and the adult) at a single computer.

Instrumentation

The pretest/posttest instrument was developed specifically for this study by the authors. Several issues arose in the development that required certain compromises. First, it was decided to explicitly address the reading skills taught in Intellitools Reading, that is, to focus on the reading skills one would expect children to attain in the first four months of reading instruction at the first grade level. Second, because of the limited amount of time available for testing, and the undesirability of testing first grade students for long periods of time, the individual subscales were brief and specifically targeted the range of proficiency, which the students might possibly achieve. Third, because it was of primary importance to measure the skills of students who had disabilities, who had potential for reading failure, and who entered the project with minimal conventional literacy skills, the instrument tended to emphasize basic skills so that all students would have success on at least some of the items. Finally, a measure that required children to read connected text was not included since none of the students in the experimental group would have been able to complete the task with even the easiest of texts at pretest. Thus, the instrument measured breadth of skills taught in the four units, with necessary compromises to depth, with the recognition that some students, particularly those in the criterion group, might ceiling on the posttest.

The instrument addressed five areas that represent the skills and understandings that children who read at the beginning-to-middle of first-grade level should be able to demonstrate as a result of instruction with the program. The five subtests are described below with more detail provided in the results section. Three of the five are curriculum-based measures (onset, rime, word identification) and two are non-curriculum-based measures (phonemic awareness and write total/developmental spelling).

Onset. Sixteen onsets were introduced in the four units and each was tested in the pre- and post-test. The onset sub-test was developed based on Cunningham et al. (1999) and combined the 16 onsets with one of three word endings: up, and, out (making nonsense words). Children were first asked to read the three word endings and were taught them if they were unfamiliar. Then the word ending was presented on the top half of a PowerPoint slide (Cunningham et al., 1999) and the onset plus word ending on the bottom half. Children were encouraged to read the word ending and then the onset plus the word ending. The focus of this subtest was the correct blending of the onset with any word ending whether or not it was the assigned ending up, and, or out.

Rime . In this assessment, the 10 rimes that were introduced in the four units were tested. The subtest combined the rimes with the onset "z" (Cunningham et al., 1999). Children were taught the task through three practice items in which z was blended with the word endings (rimes) used in the onset sub-test: up, and, out (e.g., making nonsense words such as zup, zand, zout). The focus of this subtest was the correct pronunciation of the entire rime. Consequently, children could receive credit if they made the z-word into a real word that shared the rime with the target item (e.g., shout for zout), but they could not receive credit if they substituted a vowel (e.g., reading /up/ for /ap/) or final consonant.

Phonemic Awareness. This subtest was based on the work of Snider (1997). In a study of the relationship between phonemic awareness skills in kindergarten and reading achievement in second grade, Snider was able to measure phonemic awareness in low-performing kindergarten students. The tasks from the study were adapted to address the phonemic structures included in the program; however, the phonemic structures were never taught directly. In fact, the program included no direct or explicit instruction in phonemic awareness.. The five phonemic awareness tasks were: (a) phoneme segmentation, (b) strip initial consonant, (c) substitute initial consonant, (d) rhyme supply, and (e) initial consonant same. The phoneme segmentation task required children to say each of the phonemes in a single syllable word provided by the researcher (e.g., the researcher said cat, and the child replied /kuh/ /ah/ /tuh/). The strip initial consonant task required children to supply the remaining word when the initial consonant was removed from a word supplied by the researcher (e.g., the researcher said the word bat, and the child replied at). The substitute initial consonant task required children to replace the initial consonant in a word provided by the

researcher with a consonant also provided (e.g., the researcher said the word ball and the initial consonant t, and the child replied tall). The rhyme supply task required children to supply a real or nonsense word that rhymed with a word provided by the researcher (e.g., the researcher said the word may and the children replied way, bay, or pay). Finally, in the initial consonant same task, children were required to identify the picture that began with the same initial consonant as a word provided verbally by the researcher (e.g., the researcher said the word Sam while showing the children pictures of a sun, pig, and fork; then the child replied by pointing to the appropriate picture).

Write Total and Developmental Spelling. The writing/spelling measure is an adaptation of Marie Clay's (Clay, 1993) word generation task. Students were given an IntelliKeys alternate keyboard with the standard alphabet overlay and IntelliTalk (IntelliTools, 1994) with no speech. They were taught to use the backspace key to delete errors and to press the return key at the completion of each word. Writing words letter-by-letter was not a component of the program. Students used the alternate keyboard, but never with an alphabet arrangement as used for this assessment. The alphabet arrangement was selected instead of a standard QWERTY keyboard layout to provide some control for access to the computer outside of the study or standard classroom instruction.

Students were given 10 minutes to write as many words as they could, and the researcher gave suggestions for words as needed. A word was defined as a single letter or group of letters followed by a return character. These word lists were scored in two ways: (a) the total number of words generated was counted, and (b) each word was analyzed based on a three-point scale of developmental spelling. All words that were spelled correctly received a score of 3. Words that were not spelled correctly but were recognized as words received a score of 2. All random strings of letters and copied words or letters received a score of 1.

Word Identification. The word identification subtest was a curriculum-based measure composed of words that were introduced in the four units that comprised the prototype version of the program. The word identification subtest was developed by pooling the words introduced in stories and word study activities throughout the four units. The words were then located on a number of graded word lists appearing in informal reading inventories (Johns, 1994; Leslie & Caldwell, 1995). A list of 15 words at each of three levels (preprimer, primer and first grade) was randomly selected for inclusion in the final instrument. Students were asked to read the words as they appeared on the screen in PowerPoint (Cunningham et al., 1999). The words remained on the screen for 5 seconds before the screen changed to black. The student could then take as long as required to provide a response. The time of presentation was limited since this was not a test of word analysis or decoding unknown words, but a test of identification of familiar words.

Data Analysis Procedures

The pretests and posttests were conducted in individual sessions by the site leaders at every site. Most of the students completed the tests in single sessions that lasted less than one hour with some children finishing in about half that time. The phonemic awareness subtests were given orally without the use of the computer. All of the word measures were conducted using the PowerPoint program on a Macintosh computer. The writing and spelling measure used the IntelliKeys alternate keyboard with the standard alphabet overlay and IntelliTalk (IntelliTools, 1994) with no speech.

To determine if students using the program could achieve statistically significant gains in early reading ability, six two-factor, repeated measures ANOVAs were conducted. Because the risk of Type I error increased markedly with six ANOVAs, an alpha of .01 was used for each, with a resulting experimentwise alpha of approximately .06. The within-subject factor on each ANOVA was the test (pretest or posttest) scores. The between-subject factor was group membership (experimental or criterion). Moreover, the significance of the interaction between the within-subject factor and group membership was of primary interest in this study.

For all statistical tests, estimated effects sizes are given as eta. Eta has been classified as a member of the "r family" of effect size by Rosenthal (1994) and has the advantage of being a component (as eta squared) of the SPSS program. The interpretation of effect size as "small," "medium," and "large" derives from Cohen (1988) and is equal to .10, .30, and .50, respectively. Effect size is important to determine the size of the relationship. Although a

statistical test of the null hypothesis can tell us if the difference is greater than zero, the effect size is a measure of the strength of the relationship between independent and dependent variables (Cohen, 1988; Vogt, 1993).

Results

Means, standard deviations, and maximum scores (where applicable) by test and group are displayed in Table 1. The descriptive statistics in this table indicate that, at pretest, the criterion group performed consistently higher and with less variation than the experimental group. However, at posttest the experimental group was performing at, or slightly above, the criterion group's pretest scores. At posttest, the criterion group was performing near the maximum scores on the four tests which had maximum scores (onset, rime, phonemic awareness, and total word identification).

Table 1. Means, Standard Deviations, And Maximum Scores For All Variables By Test, By Group

			TEST					
			Pretest		Posttest		Total	
Variable	Group	N	Mean	SD	Mean	SD	Mean	SD
Onset (max.=16)	Criterion	25	13.24	3.13	14.91	1.12	14.04	2.51
	Experimental	35	5.83	5.10	13.22	2.80	9.36	5.56
	Total	60	8.92	5.71	13.93	2.39	11.31	5.09
Rime (max.=10)	Criterion	25	6.28	3.17	8.87	1.63	7.52	2.84
	Experimental	35	1.00	1.73	6.56	3.16	3.66	3.75
	Total	60	3.20	3.56	7.53	2.85	5.27	3.89
Phonemic Awareness Total (max.=24)	Criterion	25	21.08	3.03	23.35	2.44	22.17	2.96
	Experimental	35	10.20	6.29	18.31	5.82	14.07	7.28
	Total	60	14.73	7.47	20.42	5.31	17.45	7.10
Write Total (no max.)	Criterion	25	16.72	7.76	21.17	9.91	18.85	9.04
	Experimental	35	14.11	6.61	19.78	7.49	16.82	7.55
	Total	60	15.20	7.17	20.36	8.53	17.67	8.23
Write Weighted Developmental Spelling (no max.)	Criterion	25	45.92	18.79	60.39	27.38	52.85	24.18
	Experimental	35	27.94	17.73	50.00	23.72	38.48	23.44
	Total	60	35.43	20.12	54.35	25.60	44.48	24.70
Weighted Total Word Id (max.=90)	Criterion	25	58.60	25.98	80.78	12.63	69.23	23.34
	Experimental	35	13.43	17.17	59.19	26.30	35.28	31.73
	Total	60	32.25	30.80	68.22	24.03	49.45	33.02

The results of the within-subjects (test) main effects and interaction ANOVAs along with the effect sizes (eta) are presented in Table 2. All of the test (within-subjects) main effects were found to be statistically significant at an alpha of .01, and the test by group interactions were statistically significant for all except for write total and write developmental spelling. Write total and write developmental spelling were the only two tests with no maximum score. When graphed, the scores on these two tests rose at a similar rate for both groups, thus no interaction was discernable. The effect sizes (.66 to .85) for all the within-subjects main effects were relatively large, except for

write total, which was lower (.52). The interaction effect sizes for onset, rime, phonemic awareness total, and weighted total word identification were moderate to relatively large (.45 to .62) but small for write total and write weighted developmental spelling (.00 and .17, respectively).

Table 2. ANOVA Results For The Within-Subject Variable (Test) And The Interaction With Group.

Source	F	Eta	Within-group MS Error
Within-subjects			
Onset	61.87*	.73	8.68
Rime	118.78*	.83	3.85
Phonemic Awareness Total	102.49*	.81	7.19
Write Total	19.65*	.52	34.84
Write Weighted Developmental Spelling	41.46*	.66	204.95
Weighted Total Word Id	132.84*	.85	220.74
Test by group interactions			
Onset by group	23.15*	.55	8.68
Rime by group	13.54*	.45	3.85
Phonemic Awareness Total by group	32.23*	.62	7.19
Write Total by group	0.22	.00	34.84
Write Weighted Developmental Spelling by group	1.86	.17	204.95
Weighted Total Word Id by group	18.27*	.51	220.74

Note: All main effect and interactions had 1 degree of freedom, and all error terms had 53 degrees of freedom
* p > .01

The between-subjects ANOVAs are shown in Table 3. All the between-group main effects were statistically significant except for write total and write developmental spelling. The lack of a main effect for these two variables contributed to the lack of interaction between test and group. The effect sizes were also small for these two variables, however, the effect sizes on the other variables were moderate (eta ranged from .37 to .44). An elaboration of the individual test follows.

Onset. At pretest, the criterion group's scores were much higher and the group had less variation (see Table 1). At posttest, both groups were performing better and with less variation. At the end of the study, the experimental group was performing at approximately the same level as the criterion group was at pretest.

Rime. This task was quite difficult for both groups at pretest. The experimental group's pretest scores were essentially zero. At posttest, both groups improved markedly overall, although the experimental group had much more variation. The criterion group's scores show a "ceiling" effect at posttest, with many students scoring at the maximum of 10.

Phonemic Awareness. This test shows a classic "ceiling" effect for the criterion group. The maximum score on this test was 24 with half the criterion group scoring at 22 (the median) at posttest. Nevertheless, the experimental group was, over the course of the study, able to almost double its mean score, and approach the performance of the criterion group.

Write Total. Although the gains on this test were the most modest for both groups, the experimental group did better than the criterion group as evidenced by the experimental group's higher median scores at post-test.

Write Developmental Spelling. Both groups found this test difficult at pretest. At posttest, however, both groups were performing at a similar level, with the experimental group making greater gains (i.e., the mean of the experimental group increased by more than 21 points while the criterion group's mean increased by 13).

Word Identification. This test shows substantial gains by the experimental group and a slight "ceiling" effect for the criterion group. Of note, however, is the very large gain by the experimental group, with their mean quadrupling and their median increasing by almost 60 points.

Table 3. ANOVA Table by Group Membership (Between-subjects Variable)

Source	F	Eta	Between-group MS Error
Onset	30.63*	.51	17.18
Rime	39.71*	.61	9.24
Phonemic Awareness Total	39.32*	.66	43.32
Write Total	1.23	.14	80.83
Write Weighted Developmental Spelling	6.90	.35	778.57
Weighted Total Word Id	42.29*	.66	726.06

Note: All main effects had 1 degree of freedom, and all error terms had 53 degrees of freedom.
* $p > .01$

Discussion

This study is a preliminary investigation of a new approach to early reading instruction that is adjunctive in nature, able to be taught by a wide variety of school personnel, and primarily delivered via computer technology. The study had several limitations that must be considered in light of the results, including: (a) the lack of a true control group, (b) possible interpretation problems resulting from ceiling effects, and (c) the absence of connected text (comprehension) measures. The use of intact groups of students from two of the six sites as the criterion groups for the study limits the overall confidence in the findings. The ceiling effects evidenced in several measures limit the ability to make conclusive statements regarding real, or perceived, differences between the experimental and criterion groups.

Finally, the absence of connected text measures makes it difficult to determine the impact of the program on the student's higher-order reading skills. Overall, the findings are very encouraging and warrant additional research aimed at determining the potential contribution that the entire program may have on early reading skills in young children with disabilities, and those who are at-risk of reading failure.

The results of the 16-week period of intervention are encouraging because of the magnitude of literacy learning within such a relatively short intervention period. Although the authors had confidence that the program would assist otherwise struggling readers in their efforts to learn how to read, such dramatic effects in the abbreviated intervention period were not anticipated. For instance, even though the experimental group students started far behind the criterion group in the use of Onsets, they were able to demonstrate substantial and significant gains by the end of the study. These effects were also observed in the word identification subtest, where a significant gain in word identification was achieved without any rote drill and practice or repeated exposures to words in isolation. Instead, children encountered words in anchor stories and little books in each unit and used them as whole words (as opposed to letter-by-letter spelling) in the structured writing activities that were a part of the intervention

program. Finally, of particular interest were the significant results found in the subtests of phonemic awareness, writing and developmental spelling. During the course of this study, there were no formal opportunities for children to learn phonemic awareness skills or use a complete alphabet keyboard to write words; however, the findings in these measures suggest that children developed these skills as a by-product of the instruction in the program.

The students in this study, coming from different geographic regions throughout the United States, from a variety of school settings, and with a variety of disabilities all achieved measurable gains in their phonemic awareness, word reading, and word writing skills. A number of the students had been involved in intensive efforts to develop their reading and writing skills prior to joining the project, and many were repeating what had been an unsuccessful first-grade year. Additional investigations of longer duration and without the limitations of this study are needed to validate the potential benefits attributable to a balanced approach. These results are encouraging and provide evidence that a balanced approach to early reading instruction delivered via a carefully constructed computer-based program can be highly effective in increasing a variety of critical skills in young children at risk of reading failure.

This study investigated the effects of a software-based early reading program on the early reading abilities of first grade students with disabilities or who had potential for reading failure. Balanced reading instruction was the instructional approach because of increasing evidence that effective reading instruction must strike a balance between opportunities to read and write connected text and instruction in word identification (including phonics/decoding instruction). The study included students from inclusive classrooms in six different states and was conducted during the 1998-1999 school. Students in the experimental group evidenced a wide range of disabilities, but shared a common and identifiable problem with early literacy knowledge and skills. A group of typically-developing students served as the criterion group for the study. The results indicated that all the within-subjects main effects were statistically significant at an alpha of .01, and the test-by-group interactions were statistically significant for all measures except for two subtests. A perspective on the significant gains of the students in the experimental group and the need for additional research of longer duration is discussed.

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References

A Computer-based Reading Approach

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

Allington, R. L. (1994). What's special about special programs for children who find learning to read difficult? Journal of Reading Behavior, 26, 1-21.

Allington, R. L. (1997). Whose claims are valid? School Administrator, 54(8), 32-34.

Allington, R. L. , & McGill-Franzen, A. (1992). Unintended effects of educational reform in New York State. Educational Policy, 6, 397-414.

Barudin, S. I., & Hourcade, J. J. (1990). Relative effectiveness of three methods of reading instruction in developing specific recall and transfer skills in learners with moderate and severe mental retardation. Education and Training in Mental Retardation, 25(3), 286-291.

Clay, M. (1993). An observational survey of early literacy achievement. Portsmouth, NH: Heinemann.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences. Hillsdale, NJ: Lawrence Erlbaum Associates.

Conners, F. A. (1992). Reading instruction for students with moderate mental retardation: Review and analysis of research. American Journal on Mental Retardation, 96(6), 577-597.

Cunningham, P. M., & Allington, R. (1999). Classrooms that work: They can all read and write (2nd ed.). New York: Longman.

Cunningham, J. W. (1993). Whole-to-part reading diagnosis. Reading and Writing Quarterly, 9, 31-49.

Cunningham, J. W., Erickson, K. A., Spadorcia, S. A., Koppenhaver, D. A., Cunningham, P. M., Yoder, D. E., & McKenna, M. C. (1999). Assessing Word Attack from an Onset-Rime Perspective. Journal of Literacy Research, 31(4), 391-414.

IntelliTools (in press). IntelliTools Reading [computer software]. Petaluma, CA: Author.

IntelliTools (2000). IntelliTalk II [computer software]. Novato, CA: Author.

IntelliTools (1994). IntelliPics [computer software]. Novato, CA: Author.

IntelliTools (1994). IntelliTalk [computer software]. Novato, CA: Author.

Johnston, P. A., & Allington, R. L. (1991). Remediation. In Barr, R., Kamil, M., Mosenthal, P., & Pearson, P. D. (Eds.), Handbook of Reading Research, (Vol. .2). New York: Longman.

Johns, J. (1994). Basic reading inventory: Preprimer through grade eight (6th ed.). Dubuque, IA: Kendall/Hunt.

Katims, D. (1991). Emergent literacy in early childhood specialeducation: Curriculum and instruction. Topics in Early Childhood Special Education, 11, 69-84.

Kliewer, C. (1998). Citizenship in the literacy community: An ethnography of children with Down syndrome and the written word. Exceptional Children, 64(2), 167-180.

LaBerge, D., & Samuels, S. (1985). Toward a theory of automatic information processing. In H. Singer and R. Ruddell (Eds.), Theoretical models and processes of reading (3rd ed.). (pp. 689-718).

Leslie, L., & Caldwell, J. (1995). Qualitative reading inventory II. Addison-Wesley.

McCormick, S., & Becker, E. Z. (1996). Word recognition and word identification: A review of research on effective instructional practices. Reading Research and Instruction, 36(1), 5-17.

Perfetti, C. (1985). Reading ability. Oxford.

Pressley, M. (1998). Reading instruction that works: The case of balanced teaching. NY: Guilford.

Rosenthal, R. (1994). Parametric measures of effect size. In H. Cooper & L. V. Hedges (Eds.), The handbook of research synthesis (pp. 231-244). New York: Russell Sage Foundation.

Rudolph, C. (1990). Teaching basic sight words through nursery rhymes to mildly handicapped kindergarten students. Reading Improvement, 27(1), 72-80.

Snider, V. E. (1997). The Relationship between phonemic awareness and later reading achievement. Journal of Educational Research, 90(4), 203-211.

Stanovich, K. E. (1991). Discrepancy definitions of reading disability: Has intelligence led us astray? Reading Research Quarterly, 16, 32-71.

Vogt, W. P. (1993). Dictionary of statistics and methodology: A nontechnical guide for the social sciences. Newbury Park, CA: Sage.

Weaver, C. (1998). Reconsidering a balanced approach to reading. Urbana, IL: National Council of Teachers of English.

Wharton-McDonald, R., Pressley, M., Rankin, J., Mistretta, J., Yokoi, L., & Ettenberger, S. (1997). Effective primary-grades literacy instruction - balanced literacy instruction. Reading Teacher, 50, 518-521.

Wylie, R. E., & Durrell, D. D. (1970). Teaching vowels through phonograms. Elementary English, 47, 787-791.