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THE IMPACT OF A STRUCTURED INTEGRATED LEARNING SYSTEM ON FIRST-GRADE STUDENTS' READING GAINS

Jerrell C. Cassady
Lawrence L. Smith

Ball State University, Muncie, Indiana, USA

This study examined the effects of the Waterford Early Reading Program on reading achievement gains across the first-grade year. The results of this longitudinal analysis demonstrated meaningfully greater gains on reading achievement for those with access to the Integrated learning system (ILS) ($\eta^2 = .10$). Furthermore, the positive effects associated with access to the ILS were greatest for students demonstrating the lowest initial reading skills—those with reading skills at or below the 25th percentile at the beginning of first grade ($\eta^2 = .43$). The results are interpreted as support for the ILS in early reading instruction, provided that the ILS is fully integrated into the teachers' reading curriculum and is not used as a stand-alone program.

Perspectives on the utility and efficacy of including educational technology in early elementary classrooms range across a wide spectrum of opinion and theory, often guided by limited data. Clark (1994) summarizes the skeptic's view well when he asserts that "media will never influence learning," arguing that it is the method, not the medium, of presenting information that determines learning outcomes. Clark insists that the field of educational technology has done a poor job of demonstrating any particular learning outcomes that can be generated solely through the use of multimedia presentations,

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Address correspondence to Jerrell C. Cassady, Associate Professor of Psychology, Department of Educational Psychology, Ball State University, Muncie, IN 47306. E-mail: jccassady@bsu.edu

and essentially challenges researchers to demonstrate any unique gains to learning that can be afforded through media. Conversely, Lundberg (1995) characterized the view that the "bells and whistles" of computer technology programs were more important than the structure of the content when predicting reading gains for students with learning disabilities, stating that outcomes likely had "little to do with the logic of packaging information; the attractiveness of materials is probably more important" (p. 98).

Our theoretical orientation regarding the use of educational technology materials in the classroom falls somewhere in the middle of this continuum. Specifically, we have held the view that educational technology materials are likely to improve the learning environments for children by providing individualized learning opportunities, rich learning materials and resources, and exposure to content, ideas, and traditions that represent diverse backgrounds or disciplines. However, like most educational researchers, we noted that there were insufficient data available to endorse the widespread advocation of educational technology in classrooms (Blok, Oostdam, Otter, & Overmaat, 2002), particularly when faced with the prohibitive costs that can be associated with these materials. Given this measured optimism, we embarked on an empirical examination of the use of technology to support literacy instruction in first grade.

COMPUTERS IN LITERACY INSTRUCTION

There is a distinction in most recent discussions of computer technology between computer-assisted instruction (CAI) and integrated learning systems (ILS). Essentially, the distinction can be crudely distilled to cast CAI as the traditional ancillary computer program that has limited materials and resources used for stand-alone enrichment or remediation, and ILS as aligned with curricula and used in concert with the instructional planning process. To be clear, we maintain the distinction of CAI and ILS in reporting on prior studies.

The use of computers in the classroom has become common practice, generally with an underlying expectation that student learning can improve either through supportive skill instruction with practice (e.g., Mitchell & Fox, 2001) or by promoting a constructivist classroom context in which learners are able to have their individual growth and learning supported (Davis & Shade, 1999; Ferguson, 2001). Regardless of the underlying pedagogical orientation adopted in the classroom (skills development vs. constructivism) or the format of educational technology used in the learning process (CAI vs. ILS),

the process of effectively implementing computer-based learning materials requires providing the student with supportive learning activities that are aligned with the classroom initiatives and timed to be presented when the child needs that additional support, guidance, or scaffolding to make the classroom instruction more meaningful. In addition to helping students build skills or abilities, computers have been repeatedly proposed to promote affective orientations toward learning academic content.

In detailed reviews of the effects of technologies on literacy learning (Fitzgerald & Koury, 1996; Kamil, Intrator, & Kim, 2000), the primary theme has been that there is limited empirical research demonstrating the effects of technology, with the bulk of research in areas such as multimedia and hypermedia for children providing theoretical arguments rather than research-based outcomes. Despite the limited research, the reviews of research have demonstrated that computer-assisted instruction can promote word recognition and comprehension for children with mild and moderate disabilities (Fitzgerald & Koury, 1996), and that hypermedia and multimedia reading instruction tools show promise in building basic literacy skill and fluency for children at all levels (Kamil et al., 2000). In a meta-analysis examining 42 international studies of CAI, the overall effect size was $d = .19$, with only language of the studied population and initial differences between the experimental groups accounting for sizable variance in the results (Blok et al., 2002). That is, no particular format or content variations produced significant differences in the study effect sizes. Analyzing the effects of computers on learning for children with special needs (e.g., learning disabled or at-risk) demonstrated that learning was generally supported with technology, and that one key factor in this process was increased motivation for the literacy activities delivered via media (see also Lundberg, 1995).

DESIGN CONSIDERATIONS

Methodological procedures largely impact the conclusions that have been developed regarding the use of educational technology tools in classroom settings. To illustrate the importance of design considerations, we review the promise and peril of each of the popular research designs.

Teacher vs. Computer

Using one well-researched CAI program (*DaisyQuest*), at-risk students were noted to demonstrate significant growth and development

in phonological awareness (Mitchell & Fox, 2001). Similar outcomes were found in a related study of both drill-and-practice CAI software and a "talking book" program that was characterized as "edutainment" (Underwood, 2000). However, in both of these programs of study, when compared to a similar group of students receiving similar instructional methodologies from a teacher rather than the computer, there were no statistically significant differences. Thus, when testing the computer versus the teacher as the primary delivery agent for content, research continues to support Clark's (1994) skepticism toward media and learning. Therefore, the conclusions from these research programs would have to be that the *instructional content* was the benefit, not the mode of presenting the information.

Experimental vs. Control

The noted limitations to research pitting teacher against computer can be solved by providing the technology materials to one group and withholding instruction from the control group—which naturally has been demonstrated to provide significant gains in learning for the experimental group (see Liao, 1999, for meta-analysis). Assessing the effectiveness of *DaisyQuest* again, children from a child care center demonstrated significant gains in phonological awareness after only eight hours of interaction with the materials, as compared to a control group with no instruction (Foster, Erickson, Foster, Brinkman, & Torgeson, 1994). However, this is clearly not a reasonable approach for classroom-based research with children learning to read, given the ethical problems of withholding treatment (in this case, reading instruction).

Computer as Supplemental Instruction

Another alternative to researching the effects of technology tools in the classroom involves testing the effects of adding educational technology materials to the teacher-directed literacy instruction. This is a more realistic study of true educational applications of literacy-based educational technology, as most reading programs require a trained teacher to direct the pace, scope, and sequence of the overall instructional program. Furthermore, despite our optimism toward the utility of computers in the classroom, we are not of the opinion that children can receive optimal reading instruction in the absence of a professional reading teacher.

Examining the effects of providing an additional literacy instruction resource demonstrated that an adaptable integrated learning

system (ILS) program led to higher levels of reading performance for kindergarten children and reduced the level of off-task behavior during instructional times (van Daal & Reitsma, 2000). The data mirrored Foster et al.'s (1994) findings with the *DaisyQuest* in early childhood care facilities. However, recent research using the *DaisyQuest* materials revealed that the early gains attributed to the use of the CAI materials were eventually overcome by the comparison students when the reading curriculum finally addressed the content (Mathes, Torgeson, & Allor, 2001). Where a newer ILS is anticipated to move beyond the previous generation of CAI is in providing additional content and adaptability, overcoming the primary limitations to standard CAI packages. However, positive gains attributed to the ILS are primarily noted only in conditions where there has been "strong implementation," as compared to weak implementations that are characterized by partial or inconsistent use of the materials (van Daal & Reitsma, 2000).

A recent study examining the effects of the Waterford Early Reading Program (WERP) concluded that this comprehensive ILS targeting early literacy skills had no significant impact on the students' reading-related skills in kindergarten and first grade, using the Clay (1993) observation survey (Paterson, Henry, O'Quin, Ceprano, & Blue, 2003). This situated investigation demonstrated that classroom literacy environments and teachers' pedagogical activities were able to account for significant shares of the achievement variance, confirming our orientation that the teacher is a key and central factor in determining success.

However, in our own work with kindergarten students (Cassady & Smith, 2004), we found that kindergarten students attending a school implementing WERP demonstrate dramatically greater growth curves on phonological awareness development across three points in the academic year than a comparison school. Limitations to both studies that are inherent to school-based research support continued investigation. In our previous study (Cassady & Smith, 2004), the sample size was dramatically smaller, involved only kindergarten students, and reported only on phonological awareness gains. Our perception of the limitations to the Paterson study include:

1. **limited assurance of equality in the experimental and comparison groups on key variables, including SES, exposure to print, kindergarten readiness, and entry literacy skills used to establish the control groups. (In fact, the only classrooms to receive WERP in this evaluation study were those targeted due to high percentages of at-risk children.)**

2. **the use of a posttest-only design does not allow for the determinations of "growth" or "learning" in the analyses**
3. **teachers in the classrooms with access to WERP did not appear to actively drive the reading instruction process, placing "complete confidence in the Waterford program's ability to track student progress and to design appropriate instruction to enhance literacy growth" (Paterson et al., 2003, p. 203).**

The current investigation attempts to add to the discussion on WERP and ILS in general by exploring the effects of WERP on standardized tests of academic performance in a first-grade sample, with particular attention to the children most at-risk for reading failure.

PRESENT INVESTIGATION

The current study examines the effects of implementing the WERP-integrated learning system into first-grade classrooms taught by teachers who were involved in progressive and ongoing professional development on reading instruction. The study makes use of a longitudinal cohort analysis, examining the differences in growth from the beginning of first grade to the beginning of second grade for children separated by one year. The only notable difference in the instructional environment for the two groups was the inclusion of the Waterford Early Reading Program in the daily curriculum for the second cohort. To answer the staunchest critics of effective reading instruction with educational technology and professional development implementation, we used standardized tests of achievement as the measure for demonstrating success.

METHODS

Participants

The participants in this study were children entering first grade in two consecutive academic years at a rural school in the midwest United States. The school was affiliated with a mid-sized university through a professional development schools network and worked more deeply during this project period on developing effective reading instruction strategies and habits. There were three first-grade teachers represented in this study, all of whom maintained their positions during both years of this investigation.

Children in the first cohort (comparison group) were those entering first grade in the fall of 2000. There were 47 children (29 females, 18 males) in the comparison group who were not reported to have repeated a grade level. No reliable data were available regarding the individual students' races; however, the school serves a primarily Caucasian population (97% or greater) with 11% of the students eligible for full or partial federal assistance for school lunch programs. The second cohort (experimental group) entered first grade the following year (Fall 2001). There were 46 (25 female, 21 male) children in Cohort 2 who met the requirements listed above.

Materials & Procedures

The data for this study were drawn from a four-year study tracking the success of a professional development initiative called 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 were engaged in ongoing professional development activities and received various resources to support their delivery of effective literacy instruction. Training and reading instruction support were provided by a team of university researchers and literacy experts who joined with the project schools in the IRP.

The curriculum for the first grade was consistent across the two years of this study, with all activities driven by published state standards for reading. In particular, the teachers were charged with the task of meeting broad standards for reading that targeted word recognition, fluency, and vocabulary development; reading comprehension, including knowledge of story structures; and literary response and analysis. Naturally, individual teachers maintained control over the daily activities and specific methods of presentation, but these teachers were aligned in their focus of instruction throughout the study. Consistent order, pace, and style of instruction for the various topics of reading was assisted by regular meetings among the teachers and the university personnel providing reading instruction support.

The school made use of an adopted reading series and embedded the instructional materials from that series into 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). Following structured classroom observations using CIERA (Taylor & Pearson, 2000), reading curriculum experts characterized the teachers' instructional activities as a ''modified four-blocks''

curriculum (Cunningham, Hall, & Defee, 1991). Observations revealed that teachers used a combination of small-group and whole-group instruction during the reading period to address the daily content and standards. Teachers' self-reports using DeFord's (1985) Theoretical Orientation to Reading Profile (TORP) revealed no differences among the three teachers 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. On the TORP, the skills perspective falls between a "whole language" and "basic skills" perspectives, which is consistent with their literacy instruction framework and our characterizations following classroom observations.

The primary difference between the two years of instruction represented in this study was the implementation of a computer-based integrated learning system (ILS) to complement the existing instructional practices. As part of their involvement in the IRP, the teachers had an opportunity to select an ILS that fit within their existing literacy program, receiving financial support and technical assistance to make the implementation possible. The teachers and administrators selected the Waterford Early Reading Program (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. According to the publisher (Pearson Digital Learning, 2003),

> **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.**

The implementation of WERP required the installation of two classroom computers that were used in a function similar to stations, such that each child worked with a teacher-selected WERP activity

each day. Children were scheduled to work approximately twenty minutes per day on the program, with variations arising due to typical school interruptions (e.g., absences or school delays for weather). Children regularly met the twenty-minute expectation, and frequently there was time for children to have a second session on one day of the week on a rotating basis. Overall, analyses of children's logged time in the program revealed that the students used the computer portion of the program an average of 1,797 minutes ($SD = 278.49$), which equated to roughly 30 hours of computer-assisted reading instruction during their first-grade year.

The use of WERP was designed to serve as part of the reading curriculum, not additional time on literacy instruction. In this way, the standard treatment of WERP was to replace other compatible reading instruction activities that were deemed to be less effective or individualized. As the teachers specifically selected the WERP system due to the compatibility with the existing literacy curriculum, they reported requiring little effort 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 significant 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 support to the school. In addition to selecting upcoming modules, teachers monitored the progress through students' user accounts in order to determine skills needing further teacher support.

In addition to the computer-based program, teachers were engaged 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 at least once a week to provide this support. This training process was in operation during both the comparison and experimental years.

To track growth in reading skill, students in the comparison and experimental groups completed the CTBS Terra Nova standard batteries at the beginning of the first and second grade years. The Terra Nova reports standard scale scores that are interval-level data for all grade levels, allowing comparisons across testing periods (CTB/McGraw-Hill, 1997). The first-grade administration of the Terra Nova produces three subtest scores: reading, mathematics, and

language arts. The second grade test included additional subtests, but the focus of our analyses was on those present in both grade levels, with particular interest in the reading subscore.

RESULTS

All reported data analyses used change scores on the CTBS Terra Nova taken by children at the beginning of first and second grade (change = 2nd–1st). Initial analyses examining the effects based on teacher differences between the two cohorts or gender effects revealed no statistically significant differences. Therefore, all results are reported on simplified analyses that have removed these factors. The primary focus of the analyses was on the impact of using WERP during the first grade on the students' change scores in reading. The results revealed the experimental group ($M = 56.74$; $SD = 37.41$) demonstrated greater gains in reading performance from first to second grade than the comparison group ($M = 32.62$; $SD = 33.97$), $F(1, 91) = 10.61$, $p < .002$, $\eta^2 = .10$. Similar analyses on the subtests for language arts and math demonstrated no significant differences between the two groups ($p > .05$), suggesting that the gains were specific to the academic content area targeted by the ILS.

To more effectively examine the effect of the WERP on children at risk for reading failure, we used a quartile-split to establish three groups or students based on first-grade reading scores. The low-performance group was composed of those students scoring at the bottom 25%, the moderate-performance group included those students ranging in performance from the 26th to 74th percentiles, and the high-performance group included students scoring from the 75th percentile and up. To ensure equal representation across the two groups, a chi-square analysis was conducted (see Table 1 sample

Table 1. Beginning reading performance groups' means on grade 1 and grade 2 Terra Nova

	Low performance		Moderate performance		High performance	
Group	**Grade 1**	**Grade 2**	**Grade 1**	**Grade 2**	**Grade 1**	**Grade 2**
	$n = 11$		$n = 26$		$n = 10$	
Comparison	535.82	561.82	559.62	599.35	612.00	633.40
	(10.25)	(27.77)	(8.14)	(32.14)	(26.68)	(33.46)
	$n = 12$		$n = 20$		$n = 14$	
Experimental	535.75	610.83	561.35	617.95	608.50	649.71
	(16.09)	(26.29)	(8.93)	(36.67)	(22.06)	(38.33)

sizes for values). The chi-square confirmed that there were no significant differences between the two cohorts in representation for the first-grade performance groups, $\chi^2(2) = 1.48$.

As the primary goal of the IRP was to improve performance for the lowest-performing students in the primary grade, our analyses were focused on this population. Using the low-performance group members from the experimental and comparison samples, we conducted a univariate analysis of variance on reading performance change from first grade to second grade. The results demonstrated that the experimental group ($M = 75.08$, $SD = 29.05$, $n = 12$) enjoyed dramatically greater gains in reading performance than the comparison group ($M = 26.00$, $SD = 30.41$, $n = 11$), $F(1, 21) = 15.67$, $p < .001$, $\eta^2 = .43$ (scale score means shown in Table 1). As shown in Fig. 1, not only did the low-performance students in the experimental group outperform the low-performance students in the comparison group, they performed at a level equivalent to the comparison groups' moderate-performance students. Similar analyses for the moderate- and high-performance groups revealed that the effects of the overall growth were driven primarily by the low-performance sample. Although the experimental group demonstrated greater gain scores over time, only the low-performance group differences between the two cohorts were statistically significant. The lack of statistical significance is likely due in part to the small sample sizes in these disaggregated analyses.

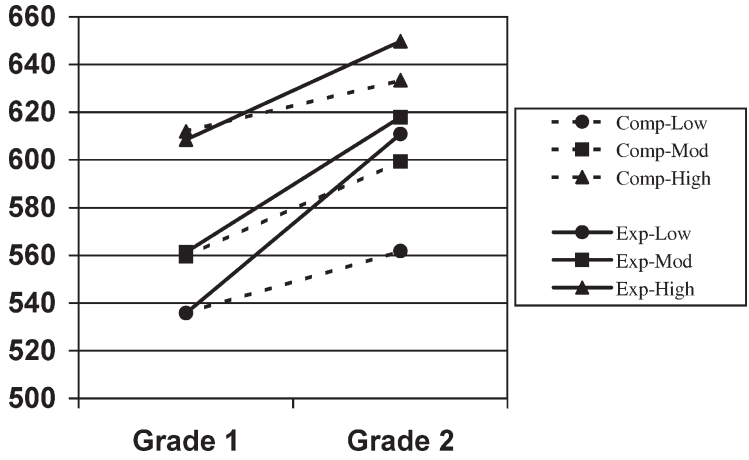

Figure 1. Reading gains for children with low, moderate, and high reading skills at first grade: Comparison versus experimental group.

One final analysis of interest was to compare the effect of WERP on students from differing levels of entry reading performance skills. That is, did access to WERP have a greater impact on the low-performance students than those in the moderate- or high-performance groups? To answer this question, we conducted a set of planned comparisons within the experimental group. The results of two planned comparison analyses demonstrated that the low-performing group enjoyed greater gains when compared to the high-performing group alone, $t(43) = 2.40$, $p = .02$, as well as when compared against the high- and moderate-performing groups, $t(43) = 2.16$, $p = .04$. Similar analyses with the comparison sample demonstrated no significant differences in level of growth among the three levels of initial reading performance ($p > .05$).

DISCUSSION

It was suggested previously that educational technology materials are likely to improve the learning environments for children by providing individualized learning opportunities, rich learning materials and resources, and contact with people and ideas from a diverse range of backgrounds. The results from this study are consistent with our view. Counter to the conclusions reached by Paterson et al. (2003), we have demonstrated evidence that the WERP led to a significant and meaningful improvement on first-grade students' reading performance. Specifically, we found that

1. **children in the experimental condition outperformed their comparison counterparts on reading performance change scores from the beginning of first grade to the beginning of second grade**
2. **the reading performance gains promoted through use of the ILS were greatest for the children at risk of reading failure, as measured by initial reading skills**
3. **there was no evidence of a "Matthew Effect" (Stanovich, 1986), where differences between high-ability students and low-ability students become enlarged as they progress through formal reading instruction. Quite to the contrary, the data from the experimental group demonstrated that the students in greatest need of reading instruction were those enjoying the greatest growth, and the gap between the high and low performers was diminished after one academic year of implementation.**

Torgeson (2000) demonstrated that most reading improvement programs had significant difficulty with bringing a critical mass of low-performing students to a successful level of performance. These ''treatment resisters'' were seen as those children who did not exceed the 30th percentile in the outcome measures related to reading skills and abilities. In our examination of Terra Nova scores at the beginning of first and second grade, we found evidence of these treatment resisters for the comparison group, who were involved only in teacher professional development and reading instruction support. However, as demonstrated in Fig. 1, students in the bottom quartile from the experimental group who had access to WERP demonstrated dramatic reading gains, performing significantly better than their low-performance counterparts in the comparison group—even displaying second-grade performance levels equivalent to the moderate-performers from the comparison sample.

Regarding children with learning difficulties, our data provide compelling evidence that the ILS is capable of promoting early literacy development. However, replication of the results reported here will likely depend on the individual teacher's ''intentionality'' toward teaching her or his students to learn to read. As the focus of the Intentional Reading Project, we were attuned to the behaviors and attitudes teachers were demonstrating throughout the two years of project implementation. Classroom observations, reports from literacy coaches, and responses to surveys all demonstrated that the teachers in our study were dedicated to making their children successful readers. Teachers' feedback after using WERP in their classrooms indicated that they saw the ILS as an additional tool to help them meet their constant goal of improving reading skills.

We believe that the ILS proved to be a particularly effective tool to help these teachers provide successful reading instruction to their students because each individual student was working progressively on those literacy development tasks that their teacher deemed key to their current levels of preparedness. While teachers engage small groups of children in guided reading instruction, the remaining students are often required to perform ''seatwork'' independently. In a classroom effectively implementing an ILS, much of this time can be spent in personalized interactive learning experiences rather than the all-too-common workbook page completion.

For teachers and administrators grappling with the decisions associated with implementing a technology-supported literacy program, our experience has repeatedly demonstrated key factors for successful implementation. First, great efforts should be taken to ensure that the ILS chosen by the school and/or classroom is one that fits with

the existing curriculum and pedagogical beliefs regarding best practices. Our principal assertion has been that the reason WERP has been successful in this study and in other empirical investigations (Cassady & Smith, 2004) was that the teachers selected WERP specifically due to the high level of concordance with state standards, the existing reading curriculum, and their school vision for literacy development. Second, teachers using WERP need to monitor the program regularly to be certain that individual students are engaged in content that is best targeting their current level of literacy readiness. The dramatic growth rate (Fig. 1) noted for the experimental group low-performance students is at least partly attributable to the teachers' continued adjustment of classroom practice and planned programmatic modification of WERP. Third, schools investing in any ILS need a clear plan for implementation support. Many of the integrated learning systems on the market today offer a limited period of excellent technical support, which is important. However, our experience with this process has demonstrated that in addition to needing to know how to turn on and deliver information through the ILS, teachers need guidance on how to make the classroom instruction mesh with the computer-based instructional activities. Overcoming the disconnect between the two modes of instruction is a difficult process for many teachers, and simple technical support will not satisfy this need. In this way, we found having one part-time support individual with expertise in reading instruction and knowledge of the ILS was sufficient to help teachers become self-sufficient in this new paradigm of instruction.

The clearest limitation to this study is the limited sample size from a single population. Particularly in light of the contradictory findings in the literature regarding the efficacy of the ILS, additional controlled research needs to be conducted to better inform literacy instruction practices. Furthermore, as we outlined in the literature review, it is important to conduct these research studies in ecologically valid conditions to more accurately capture the impact of the ILS in standard elementary school classrooms. Finally, the nature of the classroom-based research program embedded in a larger professional development program produces a potential confound that must be considered. When the experimental group progressed through first grade, their teachers had already experienced supportive professional development in reading, which may have become more polished, refined, or integrated for the experimental cohort's first grade experience. Naturally, these professional development processes were intended to make the teachers more effective reading instructors and may have contributed to the differences as well. However, in a

simultaneous intervention study with a similar school that merely used a different ILS, the pattern of results were not replicated, suggesting the training alone did not account for the reported changes.

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