Region
Midwest

Schools
2

Grade
5th

Students
146

Race & Ethnicity
- 59% African American
- 23% Caucasian
- 9% Hispanic or Latino
- 4% Asian
- 5% Other

Free/Reduced-Price Lunch
- 82%

Gender
- 53% Male
- 47% Female

Pre- & Post-Treatment Reading Achievement Measures:
- Group Reading Assessment Diagnostic Evaluation (GRADE)
- Reading Efficiency/Eye-Movement Recording (Visagraph)
- Dynamic Indicator of Beginning Early Literacy Skills (DIBELS)

Treatment
40 15-min. Reading Plus lessons (~10 hours) using 1 of 4 text presentation formats:
- Static Text Display
- Passage Build-Up
- Line by Line
- Guided Window

Effects of Four Electronic Text Presentation Formats on Reading Efficiency and Comprehension

Dissertation Summary

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Overview

The ability to read fluently and with good comprehension is a primary goal within the reading curriculum. Despite the fact that reading as a school exercise has a long-standing tradition, instructional approaches to achieve this curricular goal have varied substantially over the years. Technology has introduced new features for enhanced instructional approaches. Yet prior to this investigation, no studies have isolated the instructional impact of text presentation formats on reading development using 21st-century technology.

The goal of this study was to determine whether the exposure to a particular text presentation format as part of reading instruction (consisting of 40 fifteen-minute lessons) resulted in the same or different reading development gains achieved by fifth-grade students.

This study examined possible causal relationships between four text presentation formats and three reading achievement outcome measures. The four text presentation formats included (a) a *Static Display*, (b) a *Passage Build-Up* format, (c) a *Line-by-Line Display* (or saccadic scrolling), and (d) a *Guided Window* format that revealed and concealed text from left to right. The three reading outcome measures included (a) reading comprehension as measured by standardized test scores achieved on the Group Reading Assessment Diagnostic Evaluation (GRADE); (b) comprehension-based silent reading efficiency (reading rate, fixations [eye stops], and regressions [jump backs]) as measured by an eye-movement recording system (Visagraph); and (c) oral reading rate as measured by the criterion-referenced Dynamic Indicator of Beginning Early Literacy Skills (DIBELS).

Key Results

- ✓ All treatment groups achieved significant reading proficiency improvements as a result of reading 40 appropriately leveled text passages utilizing one of the four text presentation formats.
- ✓ Different treatment groups achieved significantly different performance improvements. The treatment group using the *Guided Window* text presentation format consistently achieved the largest improvements on all learning outcome measures. The *Line-by-Line Display* group achieved the smallest comprehension gains, and the *Static Display* group achieved the smallest reading efficiency gains.
- ✓ Improved comprehension-based silent reading efficiency behavior transferred into both GRADE reading comprehension score increases and oral reading rate improvements as measured by DIBELS.

Background

For sighted people, reading involves a "visual inspection of printed or written symbols" (Flax, 1970, p. 1). Before meaning can be constructed, data (i.e., text) must enter the brain via the eyes. How data enters the brain (i.e., how text is "seen") plays an important role in the overall reading process and, particularly, to the cognitive processing of text (Getz, 2008). Getz suggests that visual processing is learned, similar to the way walking is learned, and thus is trainable. While satisfactory eyesight is critical to the reading process, reading involves an array of visual processes (or visuomotor skills, also referred to as oculomotor skills) such as the ability to coordinate the movement of the eyes across lines of print, capture visual information, organize the information, and process the information to construct meaning (Getz, 2008). In the process of reading, the oculomotor (or visuomotor) skills are closely interrelated with the cognitive skills. The input of information directly impacts the cognitive load of information processing and meaning construction.

Text Presentation Formats – Technology has long been recognized as a valuable educational tool to enhance the teaching-learning process in unique ways. The use of adaptive instructional technology, for example, has greatly increased the feasibility of meeting individual student needs and learning styles. Technology also makes the use of innovative text presentation formats possible, yet utilizing such formats as an instructional scaffold within a 21st-century technology environment had not been isolated prior to this study. Research involving reading format has typically been limited to expository and narrative comparisons or differences between print material (or hard copy) versus screen (or soft copy) reading (Lagrou, Burns, Mizerek, & Mosack, 2006). Several studies examined reading comfort and optimal electronic text display given limited display space utilized by phones and handheld devices (e.g. Chen & Healy, 1995; Juola, Tiritoglu, & Pleunis, 1995; Kang & Muter, 1989; Öquist & Goldstein, 2003). Lemarié, Eyrolle, and Cellier (2008) studied the impact of segmented presentation of visually structured texts (i.e., restaurant menus) on comprehension. The only study that attempted to isolate a potential instructional impact of text presentation formats on reading fluency development was conducted in the 1960s. Gelzer and Santore (1968) used a mechanical instrument with a shutter-like mechanism to present text in a controlled fashion to groups of ninth-grade students. Despite the fact that the study determined that it was possible to modify reading behavior through the use of text presentation training techniques, no additional studies have revisited or elaborated on these findings.

Study Objective – The goal of this study was to determine whether exposure to different text presentation formats resulted in the same or different reading development gains.

Study Design

This study used a stratified, randomized experimental research design to examine possible causal relationships between four text presentation formats (separated into four treatment groups) and three measures of reading achievement comprising (a) reading comprehension as measured by standardized test scores achieved on the Group Reading Assessment Diagnostic Evaluation (GRADE); (b) comprehension-based silent reading efficiency (reading rate, fixations [eye stops], and regressions) as measured by an eye-movement recording system (Visagraph); and (c) oral reading rate as measured by the criterion-reference Dynamic Indicator of Beginning Early Literacy Skills (DIBELS).

The four text presentation formats are described in detail below. They included (a) a *Static Display*, (b) a *Passage Build-Up* format, (c) a *Line-by-Line Display* (or saccadic scrolling), and (d) a *Guided Window* format that revealed and concealed text from left to right within a guided window.

Static Display (control group) – Within the *Static Display* format, all reading segments within a typical lesson were displayed to students eight lines at a time. This format provided no structure or guidance of the reading process. Readers were able to read at their own pace. They had unlimited access to read and reread any portions of a displayed paragraph (Figure 1). The *Static Display* format was selected as the control format because it represents the traditional approach of presenting text. To date, this is still the most popular text presentation format used in online reading instruction.

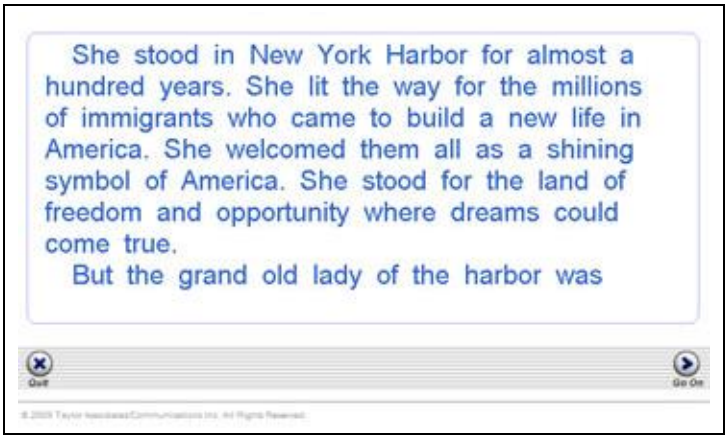

Figure 1. *Static Display* – Students read at their own pace without any onscreen guidance of the reading process. Students clicked the *Go On* button when they were ready to proceed to the next screen.

Passage Build-Up – Within the *Passage Build-Up* format, all eight-line "pages" were constructed automatically from the top down. Each new line of text was displayed below the previous line, building up to eight lines of text being presented on the screen at one time. After all eight lines were displayed on the screen, all lines automatically vanished and a new eight-line "page" build-up began at the top (Figure 2). The initial text build-up rate was calibrated by measuring students' reading rates during a rate calibration lesson that utilized the *Static Display*. Each student's text display rate was automatically adjusted during the treatment period based on individual student performance.

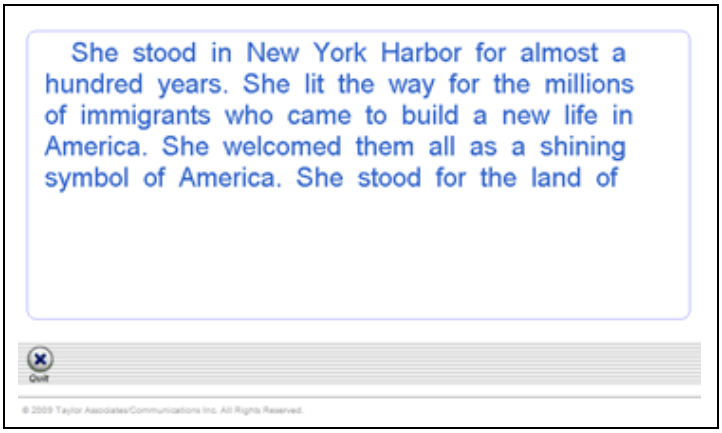

Figure 2. *Passage Build-Up* – Lines of text automatically appeared below the previous line at a pace that matched each student's current reading rate. Frames automatically advanced once eight lines were displayed on the screen.

This format provided some structure and guidance of the reading process. Similar to the *Static Display*, the *Passage Build-Up* format required authentic line transitions (or return sweeps). Navigation was simplified, however, as each new line represented a clear new beginning-line target that was easier to aim for because it was the lowest line on the screen. While text was building up, students could read along or reread text until all lines automatically vanished and a new page build-up began again at the top of the screen.

Line-by-Line Display (saccadic scrolling) – Within the *Line-by-Line Display*, all reading segments within a typical lesson were presented one line at a time (Figure 3). At any given movement in time only one line of text was displayed on the screen. Each new line of text automatically replaced the previously presented line of text. Identical to the *Passage Build-Up* format, the initial *Line-by-Line Display* rate was calibrated by measuring a student's reading rate during a rate calibration lesson that utilized the *Static Display* format. Throughout the training, display rates were adjusted automatically based on student performance and progress.

This format took the guidance of the *Passage Build-Up* format to the next level by eliminating the vertical line transitioning while encouraging the same underlying steady pace of reading. As opposed to the two formats discussed above, the *Line-by-Line Display* format provided students with restricted rereading opportunities in that only intra-line rereading was possible.

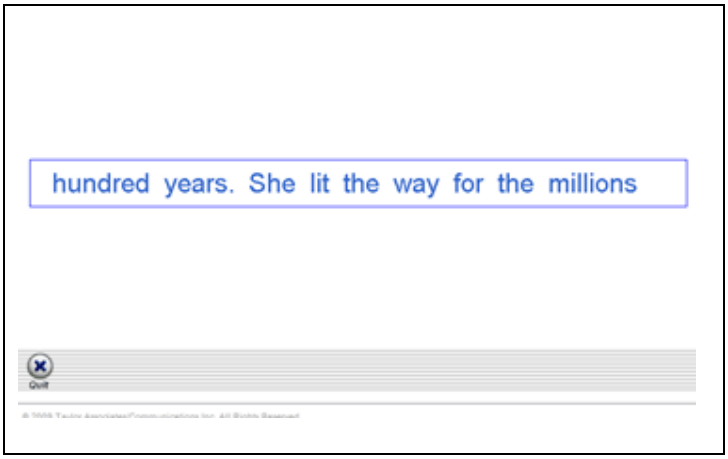

Figure 3. *Line-by-Line Display (or saccadic scrolling)* – Single lines of text were automatically displayed at a rate that matched each student's current reading rate.

Guided Window – Within this format, all reading segments were displayed within a paced window that automatically moved across lines of text in a left-to-right fashion (Figure 4). This format provided focused attention on a narrow area of text and simulated the left-to-right reading process of English language text. The guided window spanned about 30 letter spaces, providing a sufficient accommodation of an average perceptual span and other characteristics considered critical in reading. Similar to the *Passage Build-Up* and *Line-by-Line Display* formats, the automatically moving *Guided Window* assisted in maintaining a core cadence of reading.

Similar to the speed calibration in the above formats, the initial window speed was calibrated by measuring students' reading rates during a rate calibration lesson that utilized the *Static Display*. Throughout the training, the window speed was automatically adjusted based on student performance and progress. This format provided the most possible guidance of the reading process while still allowing for a largely natural process of reading.

The goal of this format was to model the left-to-right reading process of English language text while facilitating the same underlying steady pace of reading encouraged by the *Passage Build-Up* and *Line-by-Line Displays*, along with increased modeling of fluent reading behavior of adults. This format largely prevented long-rate regressions.

We know from research that regressions during reading are generally quite small. In fluent adult readers, regressions with amplitudes of up to ten character spaces account for 97% to 99% of all regressions (Vitu & McConkie, 2000). In fact, research has shown that "it is quite difficult to get readers to regress far in the text," and the "relative rarity of long-distance regressions suggest that readers avoid looking very far back in the text unless it is absolutely necessary" (Rayner & Slattery, 2009, p. 39).

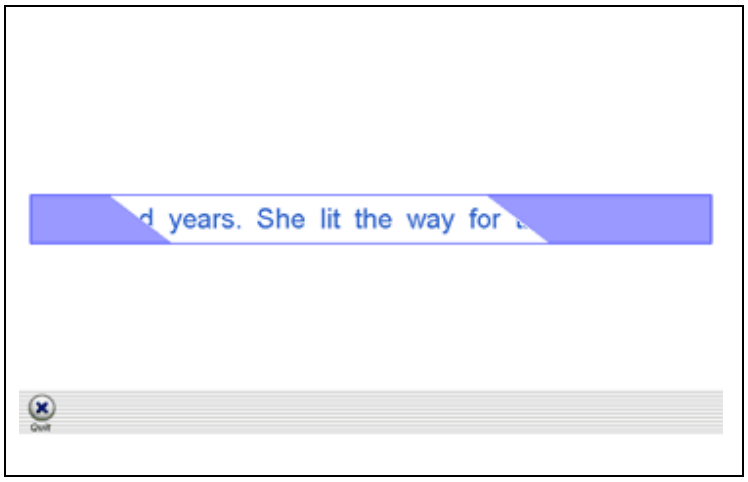

Figure 4. *Guided Window* – Text was revealed and concealed from left to right at a rate that matched each student's current reading rate.

Summary – These four text presentation formats were selected because they accommodated the theories of four popular reading processing models (e.g. EZ-Reader (Reichle, Rayner, & Pollatsek, 2003), SWIFT (Laubrock, Kliegl, & Engbert, 2006), Glenmore (Reilly & Radach, 2003), and Mr. Chips (Legge, Klitz, & Tjan, 1997)). Although all four study formats allowed for a largely authentic, connected reading experience, they were clearly different in that they provided different levels of structure and guidance of the reading process. All four presentation formats were implemented within the same web-based Java application utilizing the same reading material as well as basic text display characteristics such as line length, font type, size, and color. The objective of this study was to isolate and examine the instructional element of the text presentation format in reading fluency instruction.

Results

All treatment groups achieved significant performance improvements as a result of reading 40 appropriately leveled text passages utilizing one of the four text presentation formats. However, the different treatment groups achieved different performance improvements in regard to comprehension, silent reading efficiency, and oral reading rate. Outcomes are discussed below.

Reading Comprehension Growth – All treatment groups made significant reading comprehension gains as a result of engaging in 40 appropriately leveled 15-minute practice lessons (p <.001). On average students' reading comprehension proficiency improved by 7.9 NCE as measured by the GRADE (Figure 5). The *Line-by-Line* text presentation format group made the smallest improvements (6.2 NCE, or ~10 months' growth) and the *Guided Window* group achieved the largest gains (9.8 NCE, or ~15 months' growth). Only the group that used the *Guided Window* format achieved gains that were significantly larger than those of the other groups.

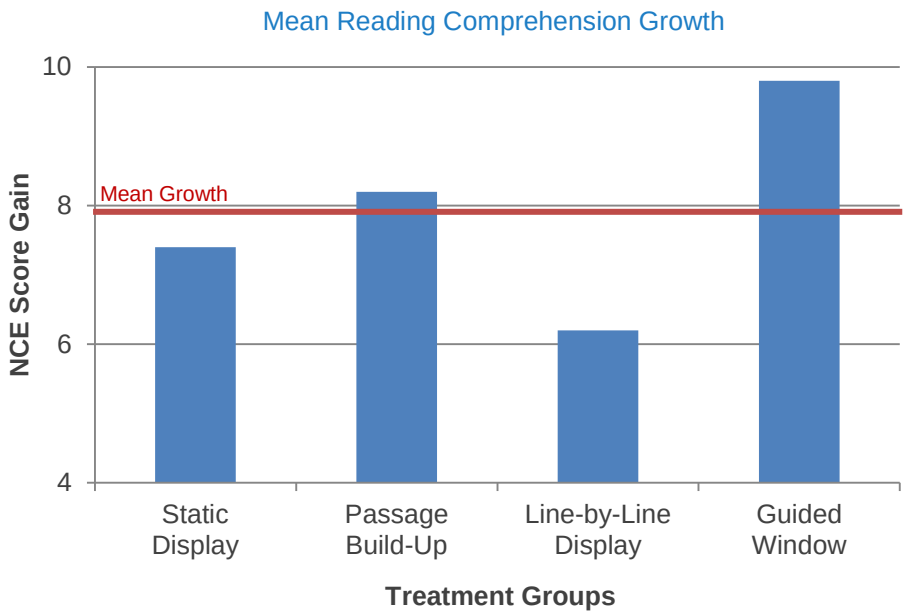

Figure 5. Mean NCE score gains achieved by the four treatment groups as measured by the GRADE.

Silent Reading Efficiency Growth – Students' reading efficiency was assessed while they read normed test passages from three different text difficulty levels (grades 1, 3, and 5) using an eye-movement recording system (Visagraph). Only comprehension-based recordings were included in the analyses (students had to complete related comprehension assessments with 70% or higher accuracy). Reading efficiency improvements varied significantly across the four treatment groups (Table 1). With the exception of the *Static Display* treatment group, all groups made significant reading efficiency improvements at all test difficulty levels ($p<.05$). The reading efficiency of the *Static Display* treatment group only improved significantly when measured using grade level 5 test passages. Across all reading efficiency measures and test difficulty levels, the reading efficiency (reading rate, fixations, and regressions) of the *Guided Window* group improved the most, and the efficiency of the *Static Display* group improved the least. The *Line-by-Line Display* group came in second and the *Passage Build-Up* group third. Comprehension-based silent reading rate improvements across the three test levels are graphed in Figure 6. The *Guided Window* group was the only group that achieved reading rate gains that were consistently above the overall growth means of all students.

Table 1. Mean Reading Efficiency Improvements by Efficiency Measures and Treatment Group

Text Presentation Formats	Reading Rate Gain (wpm)			Reduction in Fixations (eye stops)			Reduction in Regressions (jump backs)		
	Level 1	Level 3	Level 5	Level 1	Level 3	Level 5	Level 1	Level 3	Level 5
Static Display	6.9	9.1	26.3	-3.9	-7.1	-21.6	0.4	-1.1	-7.7
Passage Build-Up	12.3	20.8	30.2	-6.8	-14.1	-29.2	-2.5	-4.8	-7.7
Line-by-Line Display	21.1	24.0	31.8	-13.4	-13.5	-34.1	-3.9	-4.8	-10.0
Guided Window	28.1	32.3	42.5	-16.3	-22.3	-40.3	-6.7	-6.8	-11.9
Mean	17.1	21.5	32.6	-10.1	-14.2	-31.1	-3.2	-4.4	-9.3

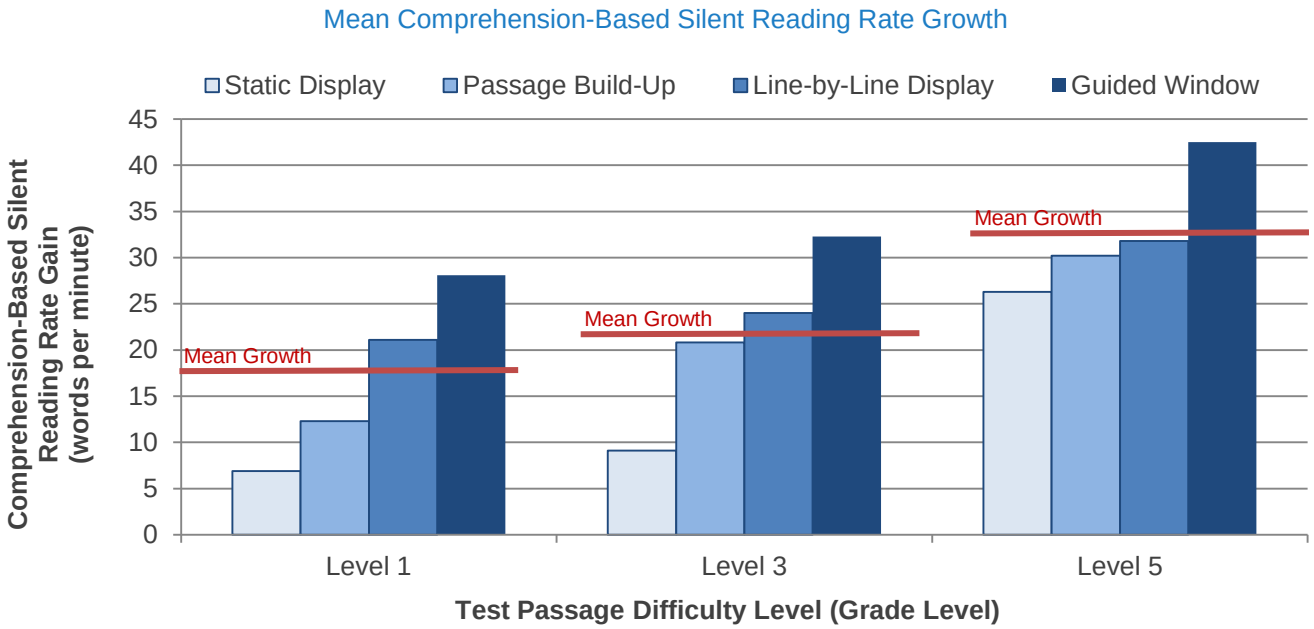

Figure 6. Mean comprehension-based silent reading rate gains achieved by the four treatment groups as measured by the Visagraph using normed test passages from three difficulty levels (grades 1, 3, and 5).

Oral Reading Rate Growth – For a subset of students (in one school) DIBELS data were collected. Results showed that on average, students' oral reading rates improved by nearly 18 correct words per minute (cwpm) between pre- and post-testing (Figure 7). To various degrees, all treatment groups improved their oral reading rates significantly ($p<.05$). The *Static Display* group improved by the smallest amount (10.4 cwpm), and the *Guided Window* group improved by the largest amount (nearly 26 cwpm). The *Line-by-Line* text presentation format group improved by about 13 cwpm and the *Passage Build-Up* group by about 19 cwpm.

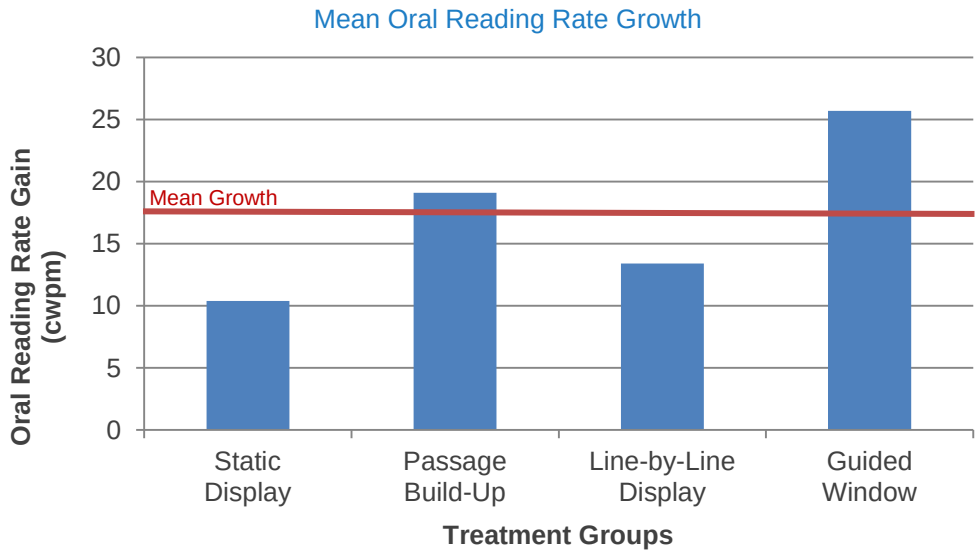

Figure 7. Mean oral reading rate gains achieved by the four treatment groups as measured by the DIBELS.

Conclusion

This study showed that simply engaging students in 40 appropriately leveled reading lessons resulted in reading proficiency improvements regardless of how text was presented to students. However, the different treatment groups achieved significantly different amounts of performance improvements as highlighted by the three types of learning outcomes that were measured: (a) reading comprehension improvements; (b) comprehension-based silent reading efficiency improvements; and (c) oral reading efficiency improvements. The *Guided Window* group consistently achieved the largest gains across all measures. While the *Line-by-Line Display* group achieved the smallest comprehension gains, the *Static Display* group achieved the smallest reading efficiency improvements. These findings are important because the study also revealed that improved comprehension-based silent reading behavior significantly transferred into both reading comprehension proficiency (r=.5; p<.001) and oral reading fluency (r=.7; p<.001).

While previous studies may have utilized certain text presentation formats to investigate the process of reading, prior to this study no research had isolated the training effects of text display formats. This study marks only the beginning of investigations needed to fully explore the potential of technology beyond providing visually stimulating learning environments and toward more fully understanding instructional implications and opportunities of digital text formats.

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