SUPPORTING FOURTH-GRADE STUDENTS' WORD IDENTIFICATION USING APPLICATION SOFTWARE

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A quasi-experimental study examined effects of a 10-week word structure intervention with fourth-grade students. During daily 10–15-minute practice periods, students worked individually with mobile apps focused on specific aspects of word identification. Pre- and post-treatment assessments showed no differences in rate and accuracy of oral reading between groups that did and did not use the apps, with little effect on motivation to read. Some differences were found in level of texts read and in spelling favoring the intervention students. However, practical significance was found in gains in percentile rank scores on standardized vocabulary and comprehension measures.

The major areas of intermediate grade literacy instruction are vocabulary development and comprehension. Many assume that children at this level have solid understanding and use of word identification skills. However, a significant number of readers may need more work on phonics and other word identification capabilities (Gunning, 2008; Shefelbine, 1990). Oral reading rates of some intermediate grade students may give false security, as word identification automaticity may not be captured in simple rate and accuracy scores (Rasinski, 2010). Some readers may have more need to develop word-level skills than is evident in traditional fluency assessment. Intervention is critical, as word identification ability remains one of the major predictors of intermediate grade students' subsequent reading comprehension (Cunningham, Nathan, & Raher, 2011).

Automaticity and Comprehension

For comprehension to be accomplished, word identification must be automatic (Just & Carpenter, 1987; Stanovich, 1996). Comprehension requires that readers reach sufficient automaticity to free attention to construct meaning (Ehri, 1996; Just & Carpenter, 1987; LaBerge & Samuels, 1974; Reutzel & Cooter, 2008). Although many readers develop those abilities at an early age, some do not and thus may benefit from focused and consistent, though brief, phonics instruction (Eldredge, 1993). Researchers have found that systematic, explicit phonics approaches are beneficial for developing the word identification skills needed for proficient reading. However, a combination of approaches can also be used effectively, including those that teach common word patterns (Gunning, 2008; Just & Carpenter, 1987; Reutzel & Cooter, 2008).

Word Patterns

Research suggests consistent word patterns in the English language that should be taught, including digraphs, trigraphs, consonant blends, silent letter combinations, single vowels, vowel teams, vowel-r combinations, and vowel-consonant-e (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Reutzel and Cooter (2008) recommended the CVC, CVVC, VCE, and CV word patterns for phonics instruction (p. 108–109). McCormick (1995) emphasized instruction with r-controlled vowels and special vowel combinations, since although r-controlled vowels have a high degree of consistency, the *er, ir,* and *ur* combinations can represent the same sound and thus be confusing for readers. McCormick (1995) also highlighted special vowel combinations that should be taught: "Studies by M. H. Bailey (1971) and others indicate that these special vowel combinations are important to teach: *au* (caught), *aw* (raw), *oi* (boil), *oy* (toy), *oo* (cool), *oo* (foot), *ou* (out), and *ow* (cow) or *ow* (snow)" (p. 318).

Challenges that face readers often intensify in the intermediate grades when textual demands increase and students' attitudes toward reading begin to decline (Allington, 2002; Chall & Jacobs,

2003; Sanacore & Palumbo, 2009; Wanzek, Wexler, Vaughn, & Ciullo, 2009). The increased demands faced by intermediate grade students lead many of them to fall behind peers (Farris, Werderich, Nelson, & Fuhler, 2009; Gambrell, 2011; Sanacore & Palumbo, 2009).

Mobile Application Software

Recent advances in educational technology—especially the use of mobile devices with application software (apps)—have increased in popularity for literacy instruction (McClanahan, Williams, Kennedy, & Tate, 2012). However, the effectiveness of educational apps with literacy instruction for intermediate grade readers needs to be explored in greater depth (Hutchison, Beschorner, & Schmidt-Crawford, 2012).

The literature shows that few research studies have been conducted concerning use of mobile devices and educational application software for literacy instruction—especially with readers in the intermediate grades (Hutchison et al., 2012; McClanahan et al., 2012). This study examines effects of using apps to help intermediate grade readers practice specific word structure patterns designed to help them achieve greater word identification skills that may strengthen fluency, vocabulary, and comprehension. The application software used in this study was designed to provide multi-sensory instruction in common English word patterns for students who struggle with word identification.

Research Questions

The purpose of this study was to examine the effectiveness of word structure practice using application software with fourth-grade readers. This study had two specific research questions:

1. How does daily practice with word structure application software affect fourth-grade students' scores on reading rate, accuracy, spelling, vocabulary, and comprehension measures?
2. How does daily practice with word structure application software affect fourth-grade students' motivation to read?

Methodology

Participants

Study participants attended an elementary school in the western United States with a population of nearly 900 students. Approximately 15% of the students received free or reduced-price lunch. The school had an 8% minority population, and a special education rate of 8% of the total population. The minority population for the fourth grade was 11%, while the classroom participating in the study had a slightly higher minority population of 14%. The percentage of fourth-grade students receiving special education services was 11%, while the percentage for the participating classroom was 7%.

This school was on a modified-extended day schedule, with half of each teacher's students arriving early for small group instruction from 8:00–9:10 am and the other half receiving small group instruction from 2:20–3:30 pm after the others had gone home. Both groups attended school together from 9:15 am to 2:15 pm for content area and large-group literacy instruction.

A total of 29 students participated in this study: an AM group of 16 students (9 females and 7 males) and a PM group of 13 (7 females and 6 males). Participants were randomly assigned to wait-list control and intervention groups through a stratified random sample based on students' performance on the *Developmental Reading Assessment 2* (DRA2; Beaver & Carter, 2006) at the beginning of the school year. The control group consisted of 15 students (10 females and 5 males; 9 AM and 6 PM); the intervention group consisted of 14 (6 females and 8 males; 7 AM and 7 PM). In the fall, the groups' performance scores on the DRA2 were very similar. The classroom teacher was the first author in this study.

Application Software

Students used the application software independently as the teacher monitored their proper use. This application software, which is available commercially, was developed by the classroom teacher, the first author (Moser, 2012). When using the apps,

students were given multiple opportunities to independently practice building, reading, and writing the words they had previously encountered.

App Content

The application software used in this study includes eight levels of instruction with a total of 88 lessons designed to teach word patterns for one-syllable words. A brief note of levels and patterns follows:

Level	Patterns and examples
1	VC, VCC, CVC, beginning and ending digraphs (am, egg, car, ship)
2a	Beginning consonant blends
2b	Common final blends (including –*ng* and *nk*, which make short *a* and *i* long (*clang, thank, sing, and drink*)
3	Common silent letter patterns (*wrist, light*)
4	Open syllable words (*hi* and *me*)
5	Words with final *e*, including instances changing sounds of *c, g*, and *s* (*twice, place, huge, stage, rose, these*)
6	R-controlled vowels, single vowels preceding *r* sound (*shark, clerk, thirst, sport*, and *burn*)
7	a, b Common vowel combinations, including *ea* and *ou*, which make multiple sounds (*bread* and *through*)
8	L-controlled vowels (*ball, cold*), advanced R-controlled vowels (*air, ear*)

Instructional Purposes

The app lessons were designed to teach common word patterns (e.g., CVC, final e, and vowel combinations) with the parts (e.g., consonants, vowels, digraphs, and morphemes) using specific principles (i.e., segmenting, sequencing, blending, and substitution) (Gunning, 2008; Just & Carpenter, 1987; McCormick, 1995; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; Reutzel & Cooter, 2008). These components were selected to help poor readers learn sound-symbol correspondences (Just & Carpenter, 1987). Auditory, visual, and tactile modalities were included in these app lessons to help intermediate grade readers learn word structure concepts. All of

those modalities are essential in the learning process but especially with those who find words abstract and need more concrete experiences.

Substituting only one element at a time to create new words is an important strategy for readers. Teachers can use consonant or vowel substitution to help these students master sound–symbol relationships. Classroom teachers often use onsets and rimes in phonics instruction, having students substitute initial consonants, consonant clusters, or consonant digraphs (McCormick, 1995). Since vowel-sound concepts are especially troublesome for some readers (McCormick, 1995), teachers can also emphasize changing one vowel at a time (e.g., *string, strong, strung*). Furthermore, readers can be assisted in understanding the difficult concept of final e when they see the teacher shows them that the final e can be removed or replaced with CVC and digraph pattern words to make changes (e.g., *can* to *cane*; *shin* to *shine*).

STUDENTS' PROCESS

The process the students followed to progress through each app lesson included eight basic steps:

1. The words were segmented into word parts, including consonants, beginning and ending digraphs, consonant blends, single vowels, and vowel combinations.
2. The students heard each word read aloud and were instructed to place the word parts in proper sequence; incorrect responses were corrected so practice would be accurate.
3. The students were directed to point to each part of the word to identify the separate sounds they heard.
4. A voice pronounced the word to blend it for the students.
5. The students were instructed to trace the letters of the word on a white board that appeared on the screen; subsequently they were directed to write the word without seeing it, then check to see if the word they had written matched the correct spelling of the word.
6. The students were instructed to manipulate the word to create a similar word.
7. The students were asked to read the words aloud individually and touch the screen to see if they were correct.

8. The app instructed the students to type the words on the keyboard as they heard them read aloud.

Instruments

Varied instruments were used to measure types of improvement that occurred or did not occur during the app intervention.

Vocabulary and Comprehension

Forms S and T of the *Gates-MacGinitie Reading Test* (MacGinitie, MacGinitie, Maria, & Dreyer, 2000), were given to assess the level of reading achievement for vocabulary and comprehension. The vocabulary test consists of 45 multiple-choice questions that "provide a brief context followed by five other words or phrases" (p. 15). The students are required to select a vocabulary word that has the same meaning as the test word. The vocabulary words progress in level of difficulty.

The comprehension test consists of 11 passages with 48 questions designed to assess children's understanding of the reading passages. "Some of the questions require constructing an understanding based on information that is explicitly stated in the passage; others require constructing an understanding based on information that is only implicit in the passage" (MacGinitie et al., 2000, p. 15). Scores provide norm curve equivalent, percentile rank, grade equivalent, and extended scale score (MacGinitie et al., 2000). Percentile rank scores were used for this study.

Participant Reading Attitudes

The Motivation to Read Profile (Gambrell, Palmer, Codling, & Mazzoni, 1996) "assesses children's self-concepts as readers and the value they see in reading" (p. 518). The profile was administered in this study through a reading survey consisting of 20 items with a cued response administered in a group setting to measure gains in reading motivation (p. 519). It can also take place as a conversational interview including 14 open-ended free response questions administered individually to cover narrative reading, informational reading, and general reading. Either version can be administered in 15–20 minutes (p. 519).

SPELLING

Improvement in spelling was assessed with the *Words Their Way Elementary Spelling Inventory* and *Spelling-by-Stage Classroom Organization Chart* (Bear, Invernizzi, Templeton, & Johnston, 2012). This 25-word spelling test measures aspects of spelling development on a continuum progressing across five stages: (a) emergent, (b) letter name-alphabetic, (c) within word pattern, (d) syllables and affixes, and (e) derivational relations (i.e., knowledge of words that are derived by adding prefixes and suffixes).

Procedures

Literacy instruction took place in the first author's classroom during the small group period for his morning and afternoon groups. The intervention for this study was incorporated for brief periods in the context of his larger literacy program.

CONTINUING CLASS LITERACY INSTRUCTION

The teacher of this class provided 70 minutes of literacy instruction and practice for both student groups. Typical small group instruction consisted of the following organizational structure:

- 20 minutes for independent reading of self-selected reading materials (Gambrell, Marinak, Brooker, McCrea-Andrews, 2011)
- 30 minutes for guided reading groups, in which literacy mini-lessons were taught according to a grade-level curriculum map, and students read aloud to the teacher in literature books at the appropriate text difficulty (Allington, 2006)
- 20 minutes of fluency practice with a partner or in small groups, which might include buddy reading, reader's theatre, songs, and poetry (Griffith & Rasinski, 2004)

This instruction included a strong fluency component given to both treatment and intervention groups. Since reader's theatre was particularly engaging for these students, this fluency exercise occurred daily for the majority of the school year. Students who were interested were able to create their own reader's

theatre scripts and puppet shows later in the school year (Griffith & Rasinski, 2004; Rasinski, 2010).

During literacy instruction, the teacher emphasized a balance of skills and meaning while addressing the needs and interests of the students (Ormrod, 1999; Walker, 1988). Another area of emphasis was increasing the amount of text the students read at the appropriate level of difficulty through frequent and consistent practice (Allington, 2006; Rasinski, 2010).

During literacy instruction in the morning, 60 minutes were set aside for journal writing, spelling and language instruction, mini-lessons, and independent writing. In the afternoon, the teacher read aloud for 20 minutes, taught a mini-lesson for 15 minutes, and provided 20 minutes for shared reading. This instructional organization ensured that all students received approximately 185 minutes of literacy instruction and practice each school day.

App Intervention

In September, the classroom teacher assessed all fourth-grade students in the participant class using the *Developmental Reading Assessment 2* (DRA2; Beaver & Carter, 2006) to obtain an estimate of their independent reading levels (see Table 1). Each student was given an identification number and randomly assigned to an intervention or control group; two of each were organized so that both the morning and afternoon students would be included.

The study occurred over a 10-week period during the students' independent reading time, with intervention students practicing 10–15 minutes per day using the apps at the level recommended by the app software program (Moser, 2012). Participants used iPads to practice word structure patterns using one app lesson at a time in a prescribed sequence. The teacher monitored and recorded the lessons each participant practiced each day on a tracking sheet provided by the app program. After using the apps, the intervention participants practiced word identification skills in connected text rather than in isolation (Allington, 1977; Chard, Pikulski, & McDonagh, 2006; McCormick, 1995). The teacher recorded field notes regarding the app intervention, guided reading, and fluency practice during regular class literacy instruction.

TABLE 1 DRA2 Scores for Intervention and Control Groups

Fall	Control	Intervention
Students scoring below level 40	60%	57%
Range of reading accuracy	96–99%	95–100%
Range of reading rate	84–186 wpm	82–158 wpm
Number of students reading fewer than 100 wpm	6	6
Winter	**Control**	**Intervention**
Students scoring below level 50	40%	29%
Range of reading accuracy	95–99%	97–99%
Range of reading rate	94–188 wpm	101–171 wpm
Number of students reading fewer than 100 wpm	3	0
Spring	**Control**	**Intervention**
Students scoring below level 50	0%	0%
Range of reading accuracy	96–99%	96–99%
Range of reading rate	98–188 wpm	101–173 wpm
Number of students reading fewer than 100 wpm	1	0

Control group students read independently during a 20-minute period each day. When intervention group participants completed their word structure practice for the day, they joined the control group in independent reading. At the conclusion of the 10-week study, control group students received access to the same apps for a 10-week period to practice the same word structure patterns so that all students in the class could receive the benefits of the program.

Data Analysis

As mentioned previously, student progress was measured by the *Developmental Reading Assessment 2* (DRA2; Beaver & Carter, 2006), *Gates-MacGinitie Reading Test* (Forms S and T; MacGinitie et al., 2000), the *Motivation to Read Profile* (Gambrell et al., 1996), and the *Words Their Way Elementary Spelling Inventory*, and *Spelling-by-Stage Classroom Organization Chart* (Bear et al., 2012). These instruments were administered to all fourth graders in the study classroom at the beginning of the school year in late August and early September and re-administered in late January and early February. Guidelines that accompany the apps were used to

obtain an estimate of where to begin instruction, and a tracking sheet was used daily throughout the study.

To answer the research questions, an Analysis of Covariance (ANCOVA) was used for comprehension, vocabulary, self-concept, and value of reading. Each measure that was analyzed used the pre-test score as a co-variate and the gain for that measure as the dependent variable. Both the treatment and gender were analyzed as independent variables. Descriptive statistics were used to show changes in intervention and control group performance on the *Words Their Way Elementary Spelling Inventory* (Bear et al., 2012).

Results

Results from this study are presented for the following dependent variables: (a) ability to comprehend, (b) level of vocabulary, (c) self-concept as a reader, (d) value for reading, (e) rate (wpm) and accuracy of oral reading, and (f) ability to spell. For each dependent variable, results were analyzed comparing intervention and control groups as well as gender categories. Levels of statistical significance and any apparent interactions are presented and discussed for the first four dependent variables. Rate and accuracy results show ranges of scores, and spelling results demonstrate changes in students' knowledge of specific word structures.

Ability to Comprehend

Comparison of Intervention and Control Groups
An analysis of covariance was conducted on results of the comprehension sub-test of the *Gates-MacGinitie Reading Test.* Participants in the control group had a mean percentile rank gain in comprehension of 12.35 (SE = 4.54), while participants in the intervention group had a mean percentile rank gain of 22.52 (SE = 4.58). Thus the mean difference was not statistically significant F (1,25) = 2.41, $p = 0.133$.

Apparent Gender Effects
Female participants' mean percentile rank gain in comprehension on the *Gates-MacGinitie Reading Test* was 17.91 (SE = 4.34); male participants' mean percentile rank gain in comprehension was 16.97 (SE = 4.78). An analysis of covariance showed that the

mean difference in observed gender effects was not statistically significant F (1,25) = 0.02, p = 0.888. No significant interactions were observed between treatment group and gender on comprehension.

Level of Vocabulary

COMPARISON OF INTERVENTION AND CONTROL GROUPS

The analysis of covariance on results of the comprehension sub-test of the *Gates-MacGinitie Reading Test* showed a mean percentile rank gain in vocabulary for the control group of 6.92 (SE = 3.09) and a mean percentile rank gain in vocabulary of 15.17 (SE = 3.10) for those in the intervention group. Again the mean difference in groups did not show statistical significance: F (1,25) = 3.40, p = 0.077.

OBSERVED GENDER EFFECTS

Although female participants had a mean percentile rank gain in vocabulary on the *Gates-MacGinitie Reading Test* of 12.31 (SE = 2.99) and male participants had a mean percentile rank gain of 9.78 (SE = 3.31), the analysis of covariance showed that this difference was not statistically significant: F (1,25) = 0.30, p = 0.592. Researchers observed no significant interaction between treatment group and gender on vocabulary.

Self-Concept as a Reader

COMPARISON OF INTERVENTION AND CONTROL GROUPS

An analysis of covariance conducted on results of the *Motivation to Read Profile* showed that students in the control group had a mean gain in their concepts of themselves as readers of 9.56 (SE = 1.84), while participants in the intervention group had a mean gain of 5.79 (SE = 1.87) in this area. The mean difference in the groups was thus statistically insignificant F (1,25) = 1.98, p = 0.171.

OBSERVED GENDER EFFECTS

The mean gain in self-concept on the *Motivation to Read Profile* was 5.20 (SE = 1.79) for female participants and 10.15 (SE = 1.99) for male students. According to an analysis of covariance, this mean difference in observed gender effects was not statistically

significant: F (1,25) = 3.20, $p = 0.086$. Again no significant interactions were observed between group and gender on self-concept as readers.

Value for Reading

The analysis of covariance on results of the *Motivation to Read Profile* revealed that control group participants' mean gain in the value they placed on reading was 4.03 (SE = 1.84), while intervention group participants' mean gain was 2.16 (SE = 1.85). As with the results on other instruments, this difference was not statistically significant: F (1,25) = 0.46, $p = 0.502$.

OBSERVED GENDER EFFECTS
The mean gain for female participants' apparent value for reading on the *Motivation to Read Profile* was 1.53 (SE = 1.71), while male participants' mean gain in value of reading was 4.66 (SE = 1.89). This difference in gender effects was revealed by an analysis of covariance to be statistically insignificant: F (1,25) = 1.42, $p = 0.245$. No significant interactions were observed between treatment group and gender on value students placed on reading.

Rate and Accuracy of Oral Reading

The *Diagnostic Reading Assessment 2* (DRA2) measured the students' oral reading rate and accuracy skills. The intervention and control groups were very similar throughout the study (see Table 2).

At the beginning of the study, students read at rates equivalent to those of students at the 75th percentile in a study by Hasbrouck and Tindal (2006). For both winter and spring

TABLE 2 DRA2 Oral Reading Rate and Accuracy Scores

	Fall		Winter		Spring	
	Rate	Accuracy	Rate	Accuracy	Rate	Accuracy
Control	110.9	97.9	121.2	97.3	127.1	97.5
Intervention	109.6	96.9	126.7	98	127.6	97.6

assessments, most students read more difficult texts than those they read during the fall when their reading rate was first measured. The reading accuracy percentages remained at 97–98% for both groups throughout the study.

Level of Text

In the fall, the control and intervention groups were relatively similar in the percentage of students reading below the DRA2 level of 40. Few differences were noted in the students' range of reading accuracy, range of reading rate, and number reading fewer than 100 words per minute (see Table 1).

However in the winter, at the conclusion of the 10-week study, some differences were observed between the two groups (see Table 1). Fewer students scored below level 50 on the DRA2 among intervention students than among control students. In addition, three students in the control group were reading fewer than 100 words per minute, while no students in the intervention group were reading below this mark.

After the 10-week study, the control group students received the same 10-week intervention with the apps. The results were relatively similar to those of the study intervention group in the percentage of students scoring below level 50, the range of reading accuracy, the range of reading rate, and the number of students reading fewer than 100 words per minute (see Table 1).

Ability to Spell

Students' spelling ability was measured using the *Words Their Way Elementary Spelling Inventory* (Bear et al., 2012). This measure reports students' abilities across five developmental stages of spelling: *emergent, letter name-alphabet, within word pattern, syllables and affixes*, and *derivational relations*. Within each of these stages a progression from *early* to *middle* to *late* is shown. The spelling abilities of all participants in this study were in the last three stages. For the intervention students, the greatest movement in scores was from the within-word stage to the syllable-affixes stage (see Table 3).

TABLE 3 Scores on the *Words Their Way Spelling Inventory* for Intervention and Control Students from Fall to Winter

	Fall									Winter								
	Within Word			Syllables-Affixes			Derivational			Within Word			Syllables-Affixes			Derivational		
	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L
Intervention Students	0.21	0.21	0.29	0.00	0.07	0.07	0.00	0.14	0.00	0.00	0.21	.21	0.07	0.21	0.07	0.07	0.14	0.00
Total		0.71			0.14			0.14			0.42			0.35			0.21	
Control Students	0.20	0.13	.13	0.07	0.20	0.20	0.00	0.07	.00	0.07	0.13	0.27	0.07	0.20	0.00	0.20	0.07	0.00
Total		0.46			0.47			0.07			0.47			0.27			0.27	

Virtually no movement was found from the within word-stage for the control group students. Nearly half of the control students remained at the within-word stage through the duration of the study. The greatest movement for these students was from syllables-affixes to derivational levels. However, these students began the study with many more students at the syllables-affixes level compared to the intervention group students.

Discussion

This study examined the effects of practice with eight specific word structures when fourth-grade readers used apps on mobile devices. Results were not what the researchers anticipated. Concerning students' motivation, we expected positive effects on their attitudes toward reading and on their self-concepts as readers as they used the apps. We believed that the intervention students would place greater value on reading than the students in the control group. Instead, we found no significant differences between the two groups on either of these aspects of motivation. The control students' gain scores were larger than those of the intervention students, but not significantly so.

We also anticipated that those students who practiced various word structures with the apps would increase their rate and accuracy of reading. Again we found no differences between the intervention and control groups. Both groups of students began the study with fairly high reading and accuracy rates, and neither group increased substantially over the course of the study.

We anticipated no difference between control and intervention group students in the level of text they would be reading at the end of the study. At the conclusion of the 10-week study, DRA2 data showed that the intervention group had a smaller percentage of students reading below level 50 than the control group. The intervention group had no students reading fewer than 100 words per minute; the control group had three.

We expected the intervention students to outperform their peers in the control group on spelling, and they did. The fourth-grade readers in this study practiced eight specific word structures over a 10-week period. Results on the *Words Their Way Elementary Spelling Inventory* (Bear et al., 2012) showed modest gains

in spelling development for intervention students in this study. The greatest gains these students made were in the spelling development stage referred to as within-word pattern, as opposed to the syllables and afffixes and the derivational relations stages. These results may indicate that additional attention to within word spelling patterns and structures using apps may help fourth-grade students make their pattern/structure use more automatic.

The surprising result of this study was that the fourth-grade readers' consistent practice on word structures over a 10-week period did lead to increases in vocabulary and comprehension scores on a standardized test. Although the results were not statistically significant, the scores did increase for the intervention students and did not decrease as they did on other measures. If more students had been included in this study and if they had performed similarly to the intervention students, statistical results may have been different. The increases imply some effect and deserve further investigation.

In order to gain proficiency with reading, individuals need to develop automatic word identification skills: the ability to identify words so quickly that they have sufficient cognitive resources available to construct meaning from text. Readers in the intermediate grades may demonstrate rates of oral reading that suggest automatic word identification but still need stronger automaticity to process text more efficiently for better comprehension. Cunningham et al. (2011) reported that speed of word recognition "accounts for a high degree of variance in comprehension throughout schooling" (p. 260). To explain what makes this rapid speed of word identification possible, researchers have proposed that readers process text orthographically as well as phonologically (Bus & van IJzendorn, 1999; Perfetti, 2007). Share and Stanovich (1995) proposed a self-teaching hypothesis to explain how orthographic processing develops. In this view, readers begin by using both phonological and orthographic processes. Gradually, they rely on orthographic features of individual words and become more adept at dealing with unique features. As they do so, they become more able to recognize patterns and generalize them to decode new words. They are finally able to automatically identify words through a coordinated use of decoding abilities and orthographic knowledge.

The readers in this study appeared to have developed greater within-word processing abilities through their practice of word structures using the application software. The increased efficiency in word identification may have increased their ability to attend more to individual word meanings and to overall text comprehension. We encourage the use of application software to allow readers to more fully automatize word identification, thus possibly increasing their ability to comprehend text and develop deeper vocabulary knowledge.

The use of apps on mobile devices did not increase these fourth graders' self-concepts as readers or raise the value they placed on reading. We did not measure the impact of using these devices on their motivation to practice. Observation of students giving each other high fives after they had completed practice sessions led us to believe that some motivation for this practice was involved. We encourage further research to clarify specific aspects of motivation that may be linked to use of application software on mobile devices to practice word structure skills.

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