

Computer-Adaptive Reading to Improve Reading Achievement Among Third-Grade Students At Risk for Reading Failure

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Abstract: An essential goal of educational instruction is to ensure that all students become competent readers. To support students in becoming qualified readers, teachers need to identify struggling students and implement adequate curriculum programs. This study examined the effects of a computer-adaptive reading program on third-grade students' reading achievement, accounting for their achievement level, their usage of computer-adaptive reading program, gender, and free and reduced lunch eligibility. Results indicated that students in the lowest academic level (below the 20th percentile; $n = 5,042$, 65.6% eligible for free and reduced lunch) and in the greatest need of intensive reading instruction evidenced greater gains than those above the 20th percentile ($n = 17,920$, 47.4% eligible for free and reduced lunch), exceeding normed expectations. On average, the achievement gap for students in the lowest academic level remained evident. The study provided evidence regarding the benefits of computer-adaptive environments to narrow achievement inequalities and increase opportunities for students who are at the greatest risk of reading failure.

Reading is the foundation of successful academic learning (Luo, Lee, & Molina, 2017). Therefore, an essential goal of educational instruction is to ensure that all students become proficient readers (DeLoza, 2013; Rabiner, Godwin, & Dodge, 2016). To support their students in becoming skilled readers, teachers need to identify struggling students and implement appropriate instruction and reading strategies (Luo et al., 2017; Putman, 2017). Given the importance of developing reading skills, educators have intensified efforts towards the improvement of students' reading, resulting in a growing number of computer-based programs intended to promote reading achievement (Carlson & Francis, 2002; Guthrie et al., 2004). Specifically, computer-adaptive reading programs (CARPs) have increased in prevalence in schools throughout the United States (Clemens et al., 2015; Flaum-Horvath, Marchang-Martella, Martella, & Kauppi, 2017; Nicolson, Fawcett, & Nicholson, 2000; Putman, 2017).

CARPs facilitate personalized learning by tailoring reading instruction. Within CARPs, students complete questions related to the reading content, and their responses provide the roadmap to adapt the curriculum to their developmental and academic needs (Luo et al., 2017). In addition, CARPs afford struggling readers opportunities to learn within their spectrum of competencies, while simultaneously building their reading efficacy and enriching their learning experience (Putman, 2017). Despite promising findings for CARPs regarding achievement growth in reading comprehension and literacy skills (Campbell, Lambie, & Sutter, 2018a; Luo et al., 2017; Patarapichayatham, 2014; Putman, 2017) and predictability studies correlating CARPs to national assessment scores (Campbell, Lambie, & Sutter, 2018b; Patarapichayatham, Fahle, & Roden, 2014), further research examining the effectiveness of CARPs is needed (Putman, 2017). Specifically, educators warrant research that examines CARPs that differentiate among students at varying academic levels to inform educational practices intended to support

students placed at risk for reading failure (Cheung & Slavin, 2012; Luo et al., 2017; Putman, 2017).

Responding to the call to improve reading among all learners and narrow achievement inequalities, the present study investigates the effects of a CARP on third-grade students' reading skills. With the increasing number of elementary school students struggling to read as well as the growing implementation of technology being integrated in general educational settings, it is essential for teachers, schools, and districts to understand the impact of educational technology on learning (Cheung & Slavin, 2013).

Background

Developing proficient reading skills continues to pose a challenge for millions of students in the United States (Yakimowski, Faggella-Luby, Kim, & Wei, 2016). According to the National Center for Educational Statistics, only 37% of fourth-grade students performed at or above the proficient level on the national assessment of educational progress (NAEP) in reading in 2017 (McFarland et al., 2018). There is evidence that without adequate intervention, students lacking fundamental reading skills in early elementary school are likely to remain behind their peers throughout their academic careers (Amendum, Vernon-Feagans, & Ginsberg, 2011; Foorman & Torgesen, 2001). Without proficient reading skills and knowledge to process and apply information from text, children are placed at risk of failing and dropping out of school (Hernandez, 2012; Rabiner et al., 2016).

Risk Factors Related to Reading Achievement

There is a link between risk factors for students' underachievement in reading and their demographic characteristics. Both students' gender and socioeconomic status (SES) significantly relate to their reading achievement and development (Buckingham, Beaman, & Wheldall, 2014; Dietrichson, Bøg, Filges, & Klint-

Jørgensen, 2017). Typically, males and students from low SES families demonstrated lower reading achievement than female students and those from higher SES families (Brown, 1991; Chatterji, 2006; Scheiber, Reynolds, Hajovsky, & Kaufman, 2015). Conversely, student factors mitigating reading underachievement include: (a) parental involvement (Crosby, Rasinki, Padak, & Yildirim, 2015; Park, & Holloway, 2017), (b) improved efficacy for reading instruction among all educational stakeholders (Goddard, Hoy, & Hoy, 2000), and (c) small-group or one-to-one instruction (Chard, Vaughn, & Tyler, 2002; Vaughn, Gersten, & Chard, 2000).

Reading Instruction

Effective reading instruction includes the following components: (a) phonemic awareness, (b) alphabetic knowledge and decoding skills, (c) fluency in word recognition and text processing, (d) vocabulary, and (e) comprehension (National Reading Panel [NRP], 2000). Typically, these reading components are provided through direct face-to-face teacher instruction (NRP, 2000; Torgerson, Brooks, & Hall, 2006). However, given the diversity of students within a classroom, traditional whole-class instruction as well as “one-size-fits-all” programs do not account for students’ individual differences and, consequently, fail to reduce the gap between struggling and proficient readers (Ivey & Broaddus, 2000). To reduce the high number of students struggling to read at grade level (Yakimowski et al., 2016), alternative or supplemental lesson structures have emerged, aiming to improve students’ reading proficiency. The investigation conducted in this study considered a computer-adaptive reading program.

Computer-Delivered Reading Instruction

Schools incorporate computer-delivered reading programs for students; however, some of these programs are nonadaptive and thus do not provide individualized instruction (Leutner, 1993; Martin & Lazendic, 2018). Specifically, computer-adaptive supplemental reading programs for students provide individualized practice and assessment of students’ reading skills to guide future instruction (Baye, Lake, Inns, & Slavin, 2016).

Consistent monitoring of students’ reading proficiency enables teachers to gain insights into their students’ strengths and areas of needs, allowing for differentiated instructional practices. Promising practices for supporting students’ reading proficiency include linking assessment data with teachers’ instruction’ including identification, planning, monitoring, and assessing. Continuous progress monitoring aids teachers in the identification of students’ reading achievement (Jenkins, Schulze, Marti, & Harbaugh, 2017).

In this investigation, the CARP considered students’ individual needs, provided continuous progress monitoring, and facilitated teachers with differential instructional planning information (Mathes, Torgesen, & Herron, 2016). The CARP was designed to adapt to students’ academic reading levels by incorporating

computer-adaptive algorithms. Through the CARP assessments, the program presented items with increasing difficulty to evaluate the students’ reading level of ability. The CARP provided teachers with information on students’ growth in the five components of effective reading instruction: phonemic awareness, alphabetic knowledge and skills, fluency, vocabulary, and comprehension (NRP, 2000).

Purpose of the Study

The purpose of the study was to examine third-grade students’ reading achievement growth as measured by Istation’s Indicators of Progress Early Reading (ISIP-ER) in terms of students’ (a) achievement level (above and below the 20th percentile), (b) minutes of CARP usage, (c) gender, and (d) free and reduced lunch (FRL) eligibility. The investigation addressed the call for research on the effectiveness of technology programs for students across all academic levels (Cheung & Slavin, 2012; Luo et al., 2017), as the effectiveness and usage of a reading intervention may vary based on students’ reading ability (Sullivan, Kohli, Farnsworth, Sadeh, & Jones, 2017). Time on task (usage in terms of the numbers of minutes of the CARP), a known indicator of reading achievement growth, warranted the investigation of minutes of use and its effects on reading achievement (Patarapichayatham, 2014). Student data were examined, comparing growth among students who used the program for the recommended number of minutes as opposed to students who did not complete the recommended minutes. Finally, the differences of reading achievement scores by student characteristics (e.g. gender and FRL that may place students at risk for reading underachievement) were examined for students most at risk for reading failure (at or below the 20th percentile). The following research question guided the investigation: Do third-grade students’ reading achievement scores change over the school year depending on their achievement level (above and below the 20th percentile) and their CARP usage when considering gender and socioeconomic status?

Method

Participants

Third-grade students’ (N = 22,962; 46.4% female and 53.6% male) achievement was measured at four points during the school year: (a) assessment at the beginning of the year (BOY), (b) assessment at midyear (MOY₁), (c) assessment at midyear (MOY₂), and (d) assessment at the end of the year (EOY). For students below the 20th percentile (n = 5,042), 65.6% were economically disadvantaged, as evidenced by their eligibility for the free and reduced lunch program, compared to 47.4% for students above the 20th percentile (n = 17,920). Those who were economically disadvantaged came from both Title I and non-Title I schools.

Students scoring at or below the 20th percentile were performing below their grade level and needed intensive reading intervention. Students’ expected

annual reading achievement growth, (derived from Istation Indicators of Progress – Early Reading (ISIP-ER) norms), included a 10-point gain for students in the lowest level of achievement (at or below the 20th percentile; Roden, 2011).

Procedure

In this study, de-identified assessment and usage data were collected during the 2016-2017 school year from participants (third-grade students) across one large Southeastern state. Students began using the CARP at the beginning of the school year in either August or September and continued using the CARP throughout the school year.

Measures

Istation Indicators of Progress – Early Reading (ISIP-ER) Assessment. The CARP automatically administers the ISIP-ER assessment at the beginning of each month, or the first time students log in to the reading program for that month. ISIP-ER incorporates a computer adaptive testing (CAT) algorithm that tailors each assessment to the achievement abilities of each individual student while measuring progress in the five critical early reading skill domains: (a) phonemic awareness, (b) alphabetic knowledge and skills, (c) vocabulary, (d) comprehension, and (e) fluency. The ISIP-ER score is reported as an Ability Index Score (Mathes, Torgesen, & Herron, 2011). During the assessment, the students are presented with test questions of varying ability scores or levels of difficulty. Once the difficulty level at which the student is able to perform is determined, the assessment ends and the student is assigned an overall reading ability index (Mathes et al., 2011). The reliability and validity of ISIP-ER scores is supported. Specifically, evidence of reliability of the ISIP-ER scores (item response theory analogue to internal consistency reliability) is approximately .90.

Usage of the CARP. School usage minutes were minutes completed at school as verified by the school system’s Internet Protocol (IP) address. Home usage included the minutes spent on the CARP at home, at a non-school library, at an afterschool program, or at a community center. Students using the CARP at home had access only to curriculum, extra reading books, and reading practice. Students did not have access to any assessments in the home environment. Students’ school and home reading usage were examined separately. The CARP utilized in this study recommended 90 minutes of CARP usage per week for students at or below the 20th percentile (Mathes et al., 2016). If a full school year is considered 30 weeks (to account for assessment periods, holidays, special programs, and days off school due to inclement weather), students at or below the 20th percentile should have completed a total of 2,700 minutes. It was possible to use the CARP beyond the regular school day, as students could access the CARP at home, at libraries, or at community centers to practice reading.

Analysis

Changes in students’ reading achievement from the beginning (BOY) to the end (EOY) of the school year within the distinct groups were examined by calculating paired sample t-tests, and Cohen’s d. Students’ achievement scores for those scoring at or below the 20th percentile (those most at risk) were examined by CARP usage, gender, and FRL eligibility.

Results

Descriptive Results

Figure 1 demonstrates the effects of the assessment and academic level interaction, indicating that all students made gains over time, with students scoring at or below the 20th percentile making greater gains in terms of increases in points. The differences in mean scores between students who scored at or below the 20th percentile versus those students who scored above the 20th percentile remained throughout third grade. The distance between growth lines were similar between the groups, meaning, on average, students in all academic levels made upward progress from assessment to assessment. Students evidenced statistically significant score improvement throughout the assessment periods from the beginning to the end of the year. Over the course of third grade, students’ above the 20st percentile achievement scores increased on average by approximately 18 points ($d = 1.2$), and students’ scores increased by almost 23 points ($d = 1.4$) for those at or below the 20th percentile.

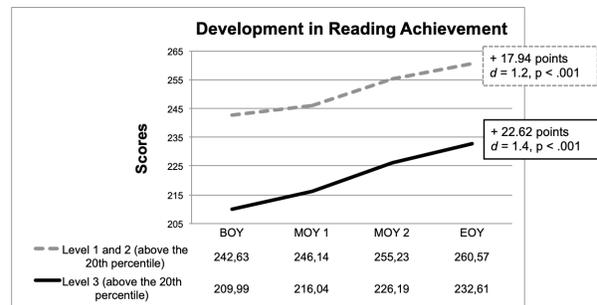


Figure 1

The change in reading achievement during third grade year (August – May)

Usage of the CARP: School and Home

In an additional step, the usage of the CARP was investigated by examining (a) the school usage and (b) the home usage for students in the lowest academic achievement level (at or below the 20th percentile). Paired sample t-tests indicated that students at or below the 20th percentile who used the CARP at home for the recommended minutes of 2,700 or more made the greatest gains in terms of points, with an average increase of 31.62 points. Students who used the program for less than the recommended number of minutes made gains, on average, of 22.56 points. Regarding school usage, students who used the program for less than 2,700

minutes evidenced an average increase of 22.68 points. Similarly, students who used the program at school for more than the recommended 2,700 minutes evidenced an average increase of 22.04 points from the beginning to the end of third grade.

Potential Risk Factors

There were differences between the achievement levels of those above and below the 20th percentile in terms of the distribution of gender and free and reduced lunch eligibility. The gender of students included more males than females. Approximately 65.6% of the students were eligible for free and reduced lunch, compared to 47.4% of the students above the 20st percentile. Independent sample *t*-tests revealed that male students (at or below the 20th percentile) scored significantly lower than female students (at or below the 20th percentile) at the beginning of the year ($M_{BOY-Male} = 208.51$; $M_{BOY-Female} = 211.61$); however, those differences narrowed by the end of the school year (EOY ; $M_{EOY-Male} = 231.90$; $M_{EOY-Female} = 233.21$), resulting in nonsignificant differences ($p = 0.73$) between male and female students (at $p < .001$).

Further, among those who were eligible for FRL and were at or below the 20th percentile, there were no significant differences at the beginning of the year; however, at the end of the year, statistically significant differences emerged. Students eligible for FRL scored slightly lower than those not eligible ($M_{EOY-FRL-ELIGIBLE} = 231.33$; $M_{BOY-NON-ELIGIBLE} = 233.97$).

Table 1 presents the results of the paired sample *t*-tests (BOY and EOY) for students by gender and FRL eligibility, accounting for school and home CARP usage. The categories less and more than 900 minutes were chosen because there were negligible differences between 900, 1,800, and 2,700 minutes of usage. For all subgroups, students made greater gains if they used the program for more than 900 minutes. Male students gained almost 27 points over the course of third grade if they used the program for more than 900 minutes at home ($d = 1.69$), equaling 30 minutes per week over a school year of approximately 30 weeks. Overall, students who were economically disadvantaged using the CARP for less than 900 minutes in school made the least amount of gains ($d = 1.10$).

Table 1 Computer-adaptive Reading for At-Risk Students

Means (M) and standard deviations (SD) in the assessments BOY and EOY and dependent statistical values of *t*-test for paired samples (*t*, *df*, *p*) and Cohen's *d* (*d*) by school and home usage for gender and socio-economic background

Students at or below the 20 th percentile											
Females						Males					
		BOY M(SD)	EOY M(SD)	Diff.	<i>t</i> (<i>df</i>)	<i>d</i>	BOY M(SD)	EOY M(SD)	Diff.	<i>t</i> (<i>df</i>)	<i>d</i>
School usage	< 900	213.11 (13.00)	234.46 (19.11)	-21.34	-18.77* (268)	1.31	211.22 (15.81)	233.27 (20.16)	-22.01	-22.90* (431)	1.22
	> 900	211.14 (13.09)	232.73 (16.30)	-21.59	-41.98* (706)	1.46	207.53 (16.19)	231.40 (19.23)	-23.87	-48.92* (1,189)	1.33
Home usage	< 900	211.62 (13.16)	233.14 (17.17)	-21.51	-43.54* (956)	1.41	208.43 (16.22)	231.71 (19.52)	-23.29	-52.10* (1,576)	1.30
	> 900	214.76 (8.43)	236.80 (15.07)	-22.04	-9.52* (18)	1.81	211.54 (14.21)	238.29 (17.32)	-26.75	-7.98* (44)	1.69
Non-disadvantaged						FRL eligible (Disadvantaged)					
		BOY M(SD)	EOY M(SD)	Diff.	<i>t</i> (<i>df</i>)	<i>d</i>	BOY M(SD)	EOY M(SD)	Diff.	<i>t</i> (<i>df</i>)	<i>d</i>
School usage	< 900	212.33 (15.36)	235.83 (19.06)	-23.59	-21.09* (291)	1.36	213.11 (13.66)	231.14 (18.66)	-18.03	-22.40* (430)	1.10
	> 900	208.75 (16.03)	233.32 (18.41)	-24.57	-44.64 (835)	1.42	209.44 (14.95)	231.38 (16.58)	-21.94	-61.07* (1,719)	1.39
Home usage	< 900	209.65 (16.04)	233.82 (18.63)	-24.17	-47.44* (1,081)	1.39	210.16 (14.69)	231.17 (17.06)	-21.01	-63.14* (2,094)	1.32
	> 900	210.33 (13.19)	237.53 (17.84)	-27.20	-10.75* (45)	1.73	210.70 (14.94)	237.32 (14.00)	-26.62	-10.57* (55)	1.84

Note. * $p < .001$

Discussion

The effects of a CARP on third-grade students' reading achievement for students scoring at or below the 20th percentile were examined in terms of usage, gender, and FRL status. The findings are discussed in relation to the following topics: (a) development of reading achievement by academic level; (b) the role of usage; (c) development of reading achievement by gender and FRL; and (d) the interrelationship between academic level, usage, and student demographics.

Development of Reading Achievement by Academic Level

Third-grade students' achievement scores improved significantly for all students regardless of their academic level when using a CARP. Students at the lowest academic level (at or below the 20th percentile) scored significantly lower throughout the school year than students in higher academic achievement levels (above the 20th percentile). However, students at or below the 20th percentile made slightly greater growth gains in terms of points and exceeded the ISIP-ER normed expectations for their academic level. The finding contributes to the field of educational research for at-risk students, in response to Cheung and Slavin's (2013) review, which concluded that "there is a limited evidence base for the use of technology applications to enhance the reading performance of struggling readers in elementary school" (p. 296). Despite students at or below the 20th percentile evidencing slightly greater gains in terms of the increase in points, their rate of progress was not sufficient to narrow the achievement gap. In fact, the reading scores of students at the lowest academic level (at or below the 20th percentile) at the end of the year remained below the scores of their counterparts above the 20th percentile from the beginning of the school year.

The Role of Usage of the CARP

With regard to students' school usage of the CARP, there were minimal differences between students who were at or below the 20th percentile who used the CARP for more than 2,700 minutes versus the students who used the program for less than 2,700 minutes but more than 900 minutes (30 minutes of usage per week for an average of 30 weeks). An examination of students' home usage of the CARP indicated students at or below the 20th percentile who used the home component for more than 2,700 minutes (on average, 90 mins per week for 30 weeks) made the greatest amount of gains in terms of growth of achievement scores with an increase of almost 32 points from the beginning to the end of third grade compared to an increase of 23 points for students who used it for less than 2,700 minutes. For these students, home usage (90 minutes per week for 30 weeks) seems to have a greater impact on achievement than just school usage, highlighting the importance of supporting students and families with home access to technology-enhanced reading instruction (KewalRamani et al., 2018).

Development of Reading Achievement by Gender and FRL Eligibility

When considering students at or below the 20th percentile by gender and FRL status, regardless of CARP usage, there were statistically significant differences by gender. At the beginning of third grade, male students scored significantly lower than female students. By the end of third grade, the achievement gap between students by gender closed and there were no significant differences in achievement. In contrast, an examination of the achievement of students classified by FRL eligibility at the beginning of the school year indicated no significant difference. By the end of the school year, students eligible for FRL scored significantly lower than students not eligible for FRL. Without accounting for the usage of CARP, the achievement gap widened by SES (when defined as FRL eligibility). These findings support the need to further investigate the role that CARPs play for narrowing the reading achievement gap (Kuder, 2017; Stevens, Walker, & Vaughn, 2017).

Interrelationship Between Students' Level, Usage, and Demographic Data

Students at or below the 20th percentile (those most academically disadvantaged, $n = 5,042$) who used the CARP in school for over 900 minutes (on average, 30 mins a week for 30 weeks) scored higher in comparison to those who used the CARP for less than 900 minutes or used it for assessment only purposes. In general, the finding supports the usage of supplemental CARP with those in the lower quartile in reading. Analysis of the results of home usage of the CARP indicated that male students at or below the 20th percentile made gains of almost 27 points from the beginning to the end of the school year if they used the home component for more than 900 minutes (which equaled 30 minutes per week over a period of 30 weeks). Not only did the gap between male and female students (at or below the 20th percentile) shrink, in fact, males outperformed the females in reading achievement over the course of third grade if they used the home component for more than 900 minutes. Moreover, students who were FRL eligible gained, on average, around 27 points when they used the home component for more than 900 minutes, indicating the need for extra remediation to have greater gains in reading achievement. Home usage of the CARP made a difference in achievement for all students, especially for male students ($d = 1.69$) and FRL-eligible students ($d = 1.84$). Overall, future efforts should focus on improving home access to technologies for all students, especially those in the greatest need of academic remediation in reading.

Limitations and Implications for Future Research

A limitation of the study concerns the lack of evidence of consistent implementation. The study did not examine how teachers implemented the CARP (Luo et al., 2017). While the study examined students' usage of

the program, teachers' implementation is equally crucial regarding the program's effectiveness and students' successful development of reading skills (Carlson & Francis, 2002). Therefore, future studies may evaluate the implementation and fidelity of the CARP, teacher training, and professional development, as these variables may provide crucial insights to the effectiveness of programs. In addition, not identifying other risk factors regarding students' academic achievement mitigates the interpretation of the results. Other factors not included in this study, such as students' attitudes and motivation, can be crucial predictors of educational achievement (Ohrman & Preston, 2014) and should be considered in other studies. Overall, the present study provided evidence supporting the use of a CARP for third-grade students in school and home settings.

In summary, the purpose of this study was to investigate third-grade students' reading achievement, accounting for academic level, usage of the CARP, gender, and FRL eligibility. The CARP appeared to be an effective tool to contribute to students' improved academic reading achievement. To narrow educational inequalities and increase students' educational opportunities, further research could examine methods that support students at risk of reading failure who are in the most need of extensive reading instruction through CARP. Additional research examining the effectiveness and implementation of CARP could inform effective CARP practices. A recommendation for professional development and teacher preparation programs includes discussing the benefits and implementation of computer-adaptive environments for reading instruction to improve achievement of all students, especially those students at the lowest achieving levels, in the quest for improving achievement inequalities.

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