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Computer Assisted Instruction in Early Literacy for African American, Economically Disadvantaged Children

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This study explores the efficacy of the Waterford Early Reading program (ERP) for teaching kindergarten and first grade students' early reading concepts. Students attended 3 elementary schools in Alabama. The treatment group used the software program whereas the control group did not use the software. Analyses revealed a significant treatment effect for kindergarten and first grade students. These results indicate that the use of a computerized adaptive software program such as ERP could have a big impact on students' reading gains.

INTRODUCTION

While acquiring basic literacy skills has long been considered among the most important elements of early childhood education, many recent efforts to improve reading instruction in U.S. primary schools have not been met with encouraging results, especially among lower-performing students (Chubb & Clark, 2013). In 2005, the National Assessment of Educational Progress (NAEP) reported that more than one-third of American fourth grade students performed at the lowest level (Below Basic) on the NAEP reading skills test, a measure of reading comprehension (National Center for Education Statistics [NCES], 2009). Recent efforts to improve reading instruction on a national scale (like the No Child Left Behind Act and its Early Reading First program) have moved public schools toward setting more specific goals for accountability and instructional methods for reading (Dee & Jacob, 2010). Results from recent Federal efforts, while encouraging in certain areas, have not proven to be unequivocally positive; scores from the 2013 NAEP show that progress in early reading achievement continues to be very slow, even though progress has been made by lower-performing students in the early grades. The 2013 test showed no significant changes in racial/ethnic gaps when compared to scores from 2011 (NCES, 2013). The relative stagnation of reading scores is especially notable when compared to the success of recent initiatives in areas like early mathematics. Clearly, making improvements to early reading instruction continues to present a significant problem for both educators and policymakers.

While some progress has been made in recent years, a large percentage of students continue to struggle with basic reading skills during their first years in school, and these difficulties can result in deficits that remain, or grow, in the later grades (Sparks, Patton, & Murdoch, 2013). Early reading difficulties can sometimes appear even before a child enters kindergarten; language and word learning skills seem to be significantly affected by early family experience (Hart & Risley, 2003; Sene´chal & Young, 2008). Whether a problem begins during or before the time a child starts school, research has noted that large differences in reading technique and achievement are made apparent as early as first grade. This becomes evident in the widening achievement gap between good readers and poor readers, known as the Matthew effect (Pfost, Hattie, Dörfler, & Artelt, 2013), presenting a need for individualized education that prevents early gaps between achievement of students.

Computer technology has changed education by allowing students and educators access to a wider range of resources to suit their needs. Computer-assisted instruction (CAI) in the classroom allows for a dynamic presentation of material, individualized instruction, and a level of engagement in the learning process that may not be possible in a more traditional classroom setting. CAI can provide immediate feedback regarding correct responses, reinforcement where appropriate, and modeling when needed. These benefits have been related to substantive student gains in knowledge (Macaruso & Rodman, 2011), and many help eliminate certain impediments to effective intervention among younger students and children at-risk (e.g., Fish, Li, McCarrick, Butler, Stanton, Brumitt, Bhavnagri, Holtrop, & Partridge, 2008). In early classrooms, reading instruction has long been the primary focus of computerized instruction, likely because reading acquisition has been shown to be closely related to later academic achievement in a variety of subjects (National Institute of Child Health & Human Development, 2000).

Not surprisingly, however, not all CAI is created equal. Just as changes to teaching techniques can make a huge difference in student growth in the classroom, the technique used to present CAI material—in addition to the effectiveness of specific programs—should always be considered. While a large number of studies have demonstrated that using CAI can be effective for supporting reading development (Cassady & Smith, 2004; Hecht & Close, 2002; MacArthur, Ferretti, Okolo, & Cavalier, 2001; Wise, Ring, & Olson, 2000) and phonological awareness (Macaruso & Walker, 2008; Mitchell & Fox, 2001), there is still a great deal of skepticism that computerized systems can provide reading instruction on the level of a human teacher in the classroom (e.g., Blok, Oostdam, Otter, & Overmaat, 2002).

Adaptive CAI uses an approach that has flexibility that allows for student individual differences in learning to be accommodated (Park & Lee, 2007). Such programs adjust both the starting point (if they include pre-assessments) and the path a student takes through the material. As mentioned previously, research examining the effectiveness of adaptive, sequence-based CAI has generally been positive. The use of adaptive learning systems in early education classrooms has resulted in greater reading abilities compared to controls for kindergartners living in poverty (Hecht & Close, 2002), English-language-learning kindergartners (Powers & Price-Johnson, 2007), suburban kindergartners (Cassady & Smith, 2004; Macaruso & Walker, 2008), and suburban first graders (Cassady & Smith, 2005; Macaruso, Hook, & McCabe, 2006; Savage, Abrami, Hipps, & Deault, 2009). A pair of studies conducted by the Center for Best Practices in Early Childhood have shown that such technology can successfully teach young students pre-literacy skills; additionally, the skills gained through CAI are longitudinally maintained over three years (Hutinger, Bell, Daytner & Johanson, 2005; Hutinger, Bell, Daytner & Johanson, 2006). Moreover, adaptive learning systems have been demonstrated to significantly increase phoneme awareness in low-performing preschoolers (Mitchell & Fox, 2001) and at-risk preschoolers and kindergartners (Lonigan, Driscoll, Phillips, Cantor, Anthony, & Goldstein, 2003) compared to a control group not utilizing the technology.

An adaptive CAI, the Waterford Early Reading Program (ERP) offers a comprehensive, computer-adaptive reading curriculum for pre-kindergarten through second grade students. ERP is divided into three levels, each of which is designed to address reading skills at a specific grade level; children will encounter material from earlier or later levels if they demonstrate themselves to be behind or ahead of other students in their age group. The program is intended to offer a complete pre-reading and reading curriculum for these grades.

The ERP software presents a wide range of multimedia-based activities in an adaptive sequence tailored to each student's initial placement and his or her individual rate of growth. Its instructional "strands" include phonological awareness, phonics, comprehension and vocabulary, reading fluency and language concepts (i.e., print concepts, grammar, and mechanics of written and spoken language). Often used in conjunction with traditional classroom instruction, ERP can also be used as a comprehensive, standalone curriculum through the offline student and teacher components.

The current study investigates the impact of adding an adaptive computer assisted instruction program to an existing kindergarten and first grade curriculum and its impact on reading scores. Specifically, the program utilized is the Waterford Early Reading Program (ERP).

METHODOLOGY

Participants

Participants were enrolled in kindergarten and first grade classes from a school district in Alabama in which over 90% of the students are African American from economically disadvantaged homes.

For the first sample group, the treatment group consisted of 78 first grade students who used CAI software for more than 600 minutes during the 2014-2015 school year. The control group consisted of 28 first grade students who did not use CAI software.

For the second sample group, the treatment group consisted of 105 kindergarten students who used CAI software for more than 1000 minutes during the 2014-2015 school year. The control group consisted of 128 students who did not use CAI software.

For the third sample group, the treatment group consisted of 189 kindergarten students who used CAI software for more than 1000 minutes during the 2014-2015 school year. The control group consisted of 94 students who did not use CAI software.

Measurements

Students in the first sample group were administered the STAR (Standardized Test for the Assessment of Reading) Early Literacy assessments at the beginning, middle, and end of the school year. The STAR assessments consist of 10 subtests, including Alphabetic Principle (AP), Concept of Word (CW), Visual Discrimination (VS), Phonemic Awareness (PA), Phonics (PH), Structural Analysis (SA), Vocabulary (VO), Sentence-Level Comprehension (SC), Paragraph-Level Comprehension (PC), and Early Numeracy (EN), and 2 additional scoring metrics, Grade Placement (GP), and Scaled Score (SS). The Scaled Score ranges from 300-900, identifying students as Early Emergent Reader (300-487), Late Emergent Reader (488-674), Transitional Reader (675-774), or Probable Reader (775-900). For first grade students, there is an added scoring metric, Estimated Oral Reading Fluency (EORF), also administered at all three times during the school year.

Students in the second sample group were also administered the STAR Early Literacy assessment.

Students in the third sample group were administered the DIBELS (Dynamic Indicators of Early Literacy Skills) reading assessment. DIBELS consists of 2-5 subtests, depending on time of year of administration, including Letter Naming Fluency (LNF), Phoneme Segmentation Fluency (PSF), Nonsense Word Fluency-Correct Letter Sounds (NWF-CLS), and Nonsense Word Fluency-Whole Words Read (NWF-WWR).

Students in the treatment groups used Waterford Early Reading program throughout the school year. Kindergarten students were expected to use the software for 15 minutes a day, 5 days a week, and first grade students were expected to use the software for 30 minutes a day, 5 days a week. Total minutes of usage of ERP for the 2014-2015 school year per group was calculated, and students below the threshold for each group were excluded from analysis.

FINDINGS

First Sample Group

T tests were conducted to examine gain differences between the groups (Figures 1-2).

STAR Grade Placement: Analysis revealed a significant difference between groups, $t(1, 57) = -2.345$, $p < .05$, due to higher gains for students who used Waterford (Mean = 0.86) than for students who did not use Waterford (Mean= 0.84).

Scaled Score: Analysis revealed a significant difference between groups, $t(1, 57) = -2.566$, $p < .05$, due to higher gains for students who used Waterford (Mean = 118.24) than for students who did not use Waterford (Mean= 58.28).

Estimated Oral Reading Fluency: Analysis revealed a significant difference between groups, $t(1, 37) = -2.820$, $p < .01$, due to higher gains for students who used Waterford (Mean = 38.48) than for students who did not use Waterford (Mean= 19.20).

Alphabetic Principle: Analysis did not reveal a significant difference between groups, $t(1, 57) = -1.589$, $p = .12$, however, higher gains for students who used Waterford (Mean = 14.83) than for students who did not use Waterford (Mean= 9.83) were observed.

Concept of Word: Analysis did not reveal a significant difference between groups, $t(1, 57) = -1.441$, $p = .16$, however, higher gains for students who used Waterford (Mean = 15.49) than for students who did not use Waterford (Mean= 10.83) were observed.

Visual Discrimination: Analysis did not reveal a significant difference between groups, $t(1, 57) = -1.353$, $p = .18$, however, higher gains for students who used Waterford (Mean = 11.54) than for students who did not use Waterford (Mean= 7.67) were observed.

Phonemic Awareness: Analysis revealed a significant difference between groups, $t(1, 57) = -2.211$, $p < .05$, due to higher gains for students who used Waterford (Mean = 19.49) than for students who did not use Waterford (Mean= 11.89).

Phonics: Analysis revealed a significant difference between groups, $t(1, 57) = -2.197$, $p < .05$, due to higher gains for students who used Waterford (Mean = 20.15) than for students who did not use Waterford (Mean= 12.39).

Structural Analysis: Analysis revealed a significant difference between groups, $t(1, 57) = -2.412$, $p < .05$, due to higher gains for students who used Waterford (Mean =20.68) than for students who did not use Waterford (Mean= 12.17).

Vocabulary: Analysis revealed a significant difference between groups, $t(1, 57) = -2.225$, $p < .05$, due to higher gains for students who used Waterford (Mean = 18.59) than for students who did not use Waterford (Mean= 11.22).

Sentence-Level Comprehension: Analysis revealed a significant difference between groups, $t(1, 57) = -2.182$, $p < .05$, due to higher gains for students who used Waterford (Mean = 21.24) than for students who did not use Waterford (Mean= 13.11).

Paragraph-Level Comprehension: Analysis revealed a significant difference between groups, $t(1, 57) = -2.509$, $p < .05$, due to higher gains for students who used Waterford (Mean = 20.00) than for students who did not use Waterford (Mean= 11.61).

Early Numeracy: Analysis did not reveal a significant difference between groups, $t(1, 57) = -1.752$, $p = .09$, however, higher gains for students who used Waterford (Mean = 17.76) than for students who did not use Waterford (Mean= 11.67) were observed.

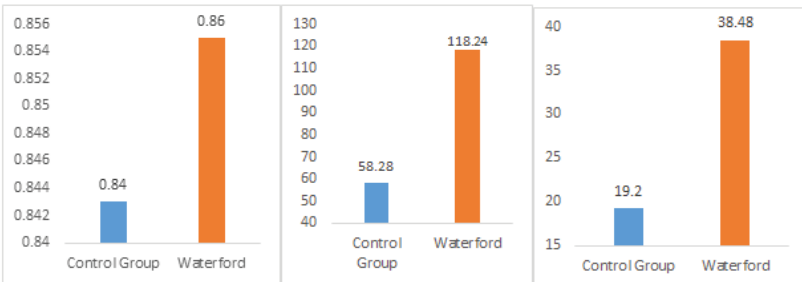

Figure 1. Mean gains by STAR scoring metric Grade Placement, Scaled Score, and Estimated Oral Reading Fluency for First Sample Group.

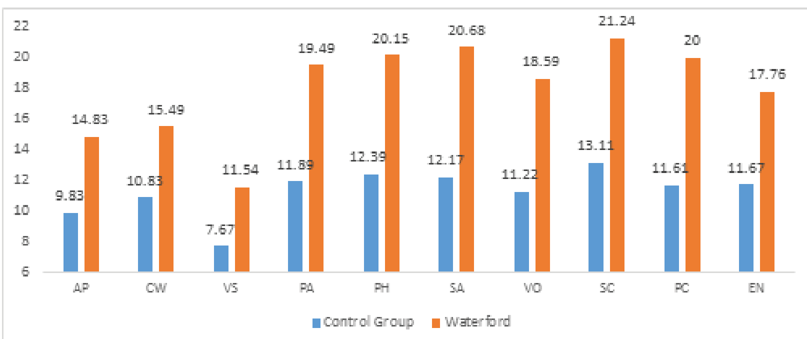

Figure 2. Mean gains by STAR Sub-Strands for First Sample Group.

Second Sample Group

T tests were conducted to examine gain differences between the groups (Figures 3-4).

Grade Placement: Analysis revealed a significant difference between groups, $t(1, 72) = 5.264$, $p < .01$, due to higher gains for students who used Waterford (Mean = .76) than for students who did not use Waterford (Mean= .68).

Scaled Score: Analysis revealed a significant difference between groups, $t(1, 139) = 2.028$, $p < .05$, due to higher gains for students who used Waterford (Mean = 170.13) than for students who did not use Waterford (Mean= 123.19).

Alphabetic Principle: Analysis revealed a difference approaching significance between groups, $t(1, 139) = 1.907$, $p = .059$, due to higher gains for students who used Waterford (Mean = 27.50) than for students who did not use Waterford (Mean= 20.46).

Concept of Word: Analysis did not reveal a significant difference between groups, $t(1, 139)$ 1.835, $p = .069$, however, higher gains for students who used Waterford (Mean = 29.07) than for students who did not use Waterford (Mean= 21.85) were observed.

Visual Discrimination: Analysis did not reveal a significant difference between groups, $t(1, 139)$ 1.439, $p = .15$, however, higher gains for students who used Waterford (Mean = 24.83) than for students who did not use Waterford (Mean= 19.42) were observed.

Phonemic Awareness: Analysis revealed a significant difference between groups, $t(1, 138) = 2.095$, $p < .05$, due to higher gains for students who used Waterford (Mean = 27.58) than for students who did not use Waterford (Mean= 20.80).

Phonics: Analysis revealed a significant difference between groups, $t(1, 138) = 2.447$, $p < .05$, due to higher gains for students who used Waterford (Mean = 27.87) than for students who did not use Waterford (Mean= 19.20).

Structural Analysis: Analysis revealed a significant difference between groups, $t(1, 139) = 2.559$, $p < .05$, due to higher gains for students who used Waterford (Mean = 26.48) than for students who did not use Waterford (Mean= 18.08).

Vocabulary: Analysis revealed a significant difference between groups, $t(1, 88) = 2.053$, $p < .05$, due to higher gains for students who used Waterford (Mean = 30.08) than for students who did not use Waterford (Mean= 23.38).

Sentence-Level Comprehension: Analysis revealed a significant difference between groups, $t(1, 138) = 2.466$, $p < .05$, due to higher gains for students who used Waterford (Mean = 28.34) than for students who did not use Waterford (Mean= 20.20).

Paragraph-Level Comprehension: Analysis revealed a significant difference between groups, $t(1, 139) = 2.22$, $p < .05$, due to higher gains for students who used Waterford (Mean = 25.47) than for students who did not use Waterford (Mean= 18.69).

Early Numeracy: Analysis revealed a significant difference between groups, $t(1, 139) = 2.173$, $p < .05$, due to higher gains for students who used Waterford (Mean = 29.10) than for students who did not use Waterford (Mean= 21.31).

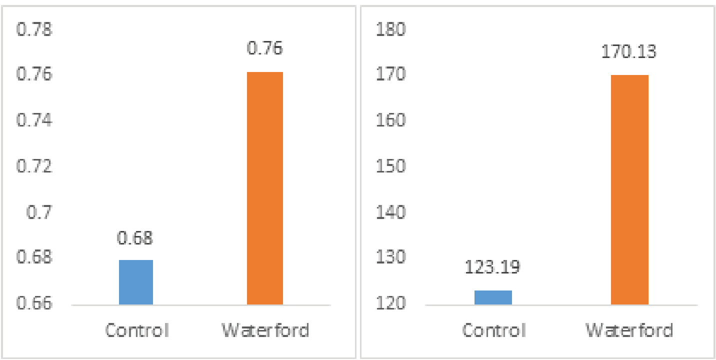

Figure 3. Mean gains by STAR scoring metric Grade Placement and Scaled Score.

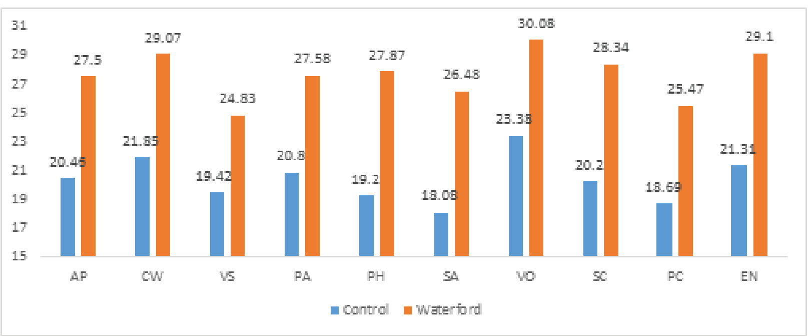

Figure 4. Mean gains by STAR Sub Strands.

Third Sample Group

T Tests were conducted to examine mean differences between post test scores (Figures 5-7).

Letter Naming Fluency: Analysis revealed a significant difference between groups, $t(1, 153) = 3.81$, $p < .01$, due to higher mean post test scores for students who used Waterford (Mean = 60.76) than for students who did not use Waterford (Mean=48.43).

Phoneme Segmentation Fluency: Analysis did not reveal a significant difference between groups, $t(1, 153) = .856$, $p = .393$, mean post test scores for students who used Waterford (Mean=56.67) were similar for students who did not use Waterford (Mean=54.20).

Nonsense Word Fluency-Correct Letter Sounds: Analysis revealed a significant difference between groups, $t(1, 153) = 3.07$, $p < .01$, due to higher mean post test scores for students who used Waterford (Mean = 49.61) than for students who did not use Waterford (Mean=37.39).

Nonsense Word Fluency-Whole Words Read: Analysis revealed a significant difference between groups, $t(1, 152) = 4.84$, $p < .01$, due to higher mean post test scores for students who used Waterford (Mean = 13.24) than for students who did not use Waterford (Mean=4.91).

Overall Composite Score: Analysis revealed a significant difference between groups, $t(1, 153) = 3.25$, $p < .01$, due to higher mean post test scores for students who used Waterford (Mean = 167.03) than for students who did not use Waterford (Mean=139.85).

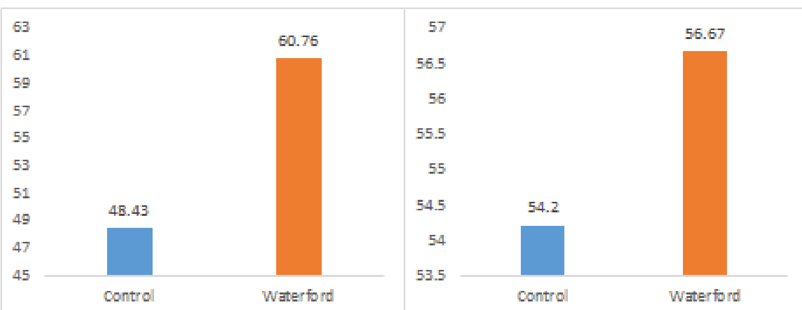

Figure 5. Mean Post Test Scores for DIBELS Sub Strands LNF and PSF for Third Sample Group.

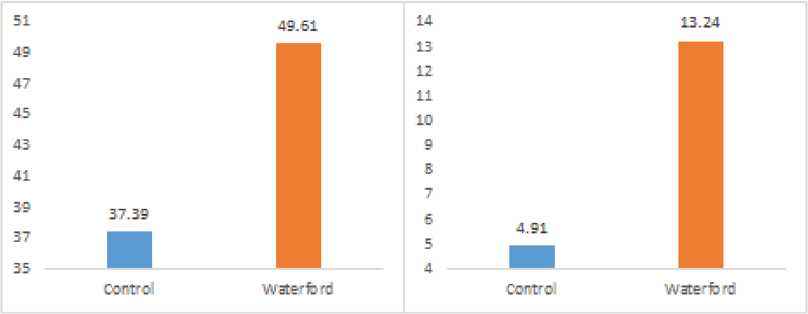

Figure 6. Mean Post Test Scores for DIBELS Sub Strands NWF-CLS and NWF-WWF for Third Sample Group.

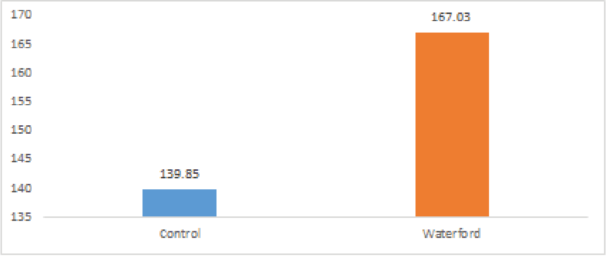

Figure 7. Mean Post Test Scores for DIBELS Composite Score for Third Sample Group.

CONCLUSIONS

Acquiring basic literacy and math skills has long been considered among the most important elements of early childhood education, yet many recent efforts to improve reading and math instruction in U.S. primary schools have not been met with encouraging results. Research suggests that different preschool programs have been shown to produce positive effects on later academic achievement, but vary greatly in effect size by the type of program (Barnett, 2010). Because early reading and math has proven to be such a difficult problem to address, future solutions should be more innovative or even revolutionary in approach while still providing rigorous theoretical and empirical justification for their usefulness.

Our findings suggest that the computer assisted instruction software has been effective in helping participants attain the emergent literacy and reading skills they need for early academic success. Based on past results in the United States (Powers & Price-Johnson, 2007), we expected to see significantly greater gains in early reading skills for students using CAI software as part of their curriculum compared to students only receiving regular classroom instruction. The current study supported our hypotheses; on most measured skills the treatment group made significantly greater gains than the control group.

Additionally, where gains were not seen, it is important to keep in mind that as with any educational intervention, an important factor that may profoundly influence outcomes is the level of implementation. A minimum of 1,000 minutes of ERP usage for the school year is expected, but that expectation had to be adjusted in order to incorporate a large enough sample size. Perhaps for areas where gains were not seen, a larger sample size with ample usage would have produced significant results. Our findings in this study suggest that if the program had been consistently implemented at the minimum expectation, students' gains would have been considerably greater than what we observed. Important to note is the appearance of gains in correlation to usage. Usage logs for students during the year indicated more consistent, and higher amounts of usage at the beginning of the 2014-2015 school year. Synonymously, the most significant gains were also seen during this time period. Despite the challenges faced by technology in education, it is becoming more and more evident that the use of computers in schooling is an effective method for teaching early literacy skills.

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