

Long-Term Effects of CAI in Early Education: Evidence from Three Districts

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Abstract: This longitudinal study involved three separate school districts and three different populations: District 1 is located in Maryland, District 2 is located in Texas, and District 3 is located in South Carolina. Students in all districts used the same computer-adaptive reading program, Waterford Early Learning (WEL), during various grades, from kindergarten through second grade. Students were all assessed at the end of their second grade year. Scores were analyzed in three distinct comparisons: overall effects, comparing students who used computer-assisted instruction (CAI) to those who did not; long-term effects, comparing students who were assessed one year after using CAI to those with no CAI usage; and early effects, comparing students who started using CAI during kindergarten compared to those who did not start until first grade. The combined longitudinal study results found that, across all districts, second grade students who used WEL outperformed their control counterparts.

Introduction

In an unprecedented review of over 100,000 research studies, the National Reading Panel paved the way for how children need to be instructed in order to learn how to read (National Reading Panel, 2000). These recommendations by the panel dramatically shifted the importance of education towards the need for rigorous research-based and evidence-based curricula, assessments, and decisions made in the classroom. The education world of today is vastly different from two decades ago because of the National Reading Panel's extensive report calling for teachers to use systematic and explicit instruction when teaching young students how to read (National Reading Panel, 2000). This report, created by a panel of experts, rigorously reviewed studies to identify five crucial components of reading: phonemic awareness, phonics, fluency, vocabulary, and comprehension (Shanahan, 2005).

Today, teachers need to use research-based curricula to teach their students these five crucial components of reading in a manner that build on one another – if a student is not an expert in phonemic awareness, for example, the student will not be able to read fluently or comprehend a text. These skills build on one another throughout a student's academic career in early elementary school, so students need research-based curricula throughout their schooling in order to obtain all the skills necessary to read fluently and comprehend. Reading achievement predicts later behavioral engagement according to one longitudinal study of elementary school literacy, implying that difficulties in reading early on may lead to lack of interest in learning to read later in school (Guo et al., 2015). A longitudinal study investigating the impact of early literacy skills in students with English as a second language found the relationship between oral language in early childhood and reading skills in elementary school to be significant (Kieffer, 2012). These findings indicate first the importance of strong reading skills in all populations, and also that strong early skills predict later literacy skills. Setting up students for success at a young age and helping them master each skill along the way could mean the difference between lack of motivation and excitement to read. Perhaps utilizing one evidence-based intervention throughout their schooling could impact their reading skills to become an expert reader.

Longitudinal research is crucial for verifying the efficacy of educational technology: Longitudinal research is defined as the study of an effect in the same participants over a period of time, such as student performance over multiple school years (APA Dictionary of Psychology, n.d.). This type of research is extremely important for the

future generations who will lead our society to be literate in reading and technology, but the statistics do not support what we need: Currently, students in the United States are not reading at the levels at which we need them to – in fact, American fourth grade students' reading proficiency declined from 2017 to 2019 (Green & Goldstein, 2019). A longitudinal study investigating evidence-based reading instruction found that students who received individualized reading instruction from first grade through third grade achieved higher reading outcomes than students who did not have individualized reading instruction for as many years (Connor et al., 2013). Despite the push towards research-based and evidence-based curricula and assessments for students, the American student population is overall declining in reading proficiency. Moreover, research-based curricula have differing definitions, and rigorous research is needed to identify the strongest curricula (Connor et al., 2013; Steiner, 2017). Teachers need the tools to support their students in reversing this downward trend in achieving reading proficiency, which could come from technology.

Longitudinal studies in the education sector are not common. More research is needed to identify the relationship between literacy skills from early on and how technology impacts literacy skills long-term, across elementary school years, and beyond. Students who use technology may not have access to consistent use of the same technology over the years – more educational technology needs to identify precisely how technology improves students' scores (Escueta, Quan, Nickow, & Oreopoulos, 2017). Although research identifies how educational technology impacts students' scores across one year, lasting effects on students' scores and behavioral engagement with their lessons could mean the difference between a short-term impact that fades and a long-term impact for years to come. To investigate this, one study compared literacy and mathematics performance gains of students from kindergarten through second grade before, during, and after implementing iPads as teaching tools in the classrooms (Bebell & Pedulla, 2015). Results showed higher reading gain scores each year made by students who used iPads compared to students who did not; however, these positive results did not extend to math achievement.

This longitudinal study involved elementary school students who used a computer-adaptive reading program, Waterford Early Learning (WEL), for up to three years, from kindergarten through second grade. The program addressed the crucial components of reading identified by the National Reading Panel, and because students used the program across their early elementary school years, they had the potential to acquire these skills through second grade. The study tested three hypotheses: (1) Students who used CAI for two or three years would have higher literacy assessment scores than students who did not use CAI, demonstrating an overall effect of CAI on literacy scores. (2) Students who used CAI for one or two years, when assessed one year after use of CAI has stopped, would have higher literacy assessment scores than students who did not use CAI, demonstrating a long-term effect of CAI on literacy scores. (3) Students who began using CAI during kindergarten would have higher literacy assessment scores than students who did not begin using CAI until first grade, demonstrating an early effect of CAI on literacy scores.

Methods

Participants

This longitudinal study included second grade students from three separate school districts (Tab. 1): District 1 consisted of students in a suburb: large public school district in Maryland during the 2017-2018 school year, District 2 consisted of students in a city: small public school district in Texas during the 2018-2019 school year, and District 3 consisted of students in a suburb: large public school district in South Carolina during the 2018-2019 school year.

Materials

Waterford Early Learning (WEL)

WEL offers a comprehensive, computer-adaptive reading curriculum for pre-kindergarten through second grade students. The 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 throughout the complete reading curriculum.

District 1: Maryland District-Administered Literacy Assessment

A literacy assessment administered at District 1 consisted of two strands for second grade students: Dictation Sounds and Dictation Words.

District 2: Texas District-Administered Literacy Assessment

A reading assessment administered to second grade students at District 2 was part of a universal reading screener.

District 3: Developmental Reading Assessment (DRA)

The DRA is a standardized reading test used to determine a student's instructional level in reading. The DRA is administered individually to students by teachers and/or literacy coaches. The DRA was administered at District 3.

Procedure

During kindergarten, students were expected to use WEL for fifteen minutes per day, five days per week, and during first and second grade, students were expected to use WEL for thirty minutes per day, five days per week. Usage was tracked within the program and monitored weekly, and total minutes of usage of WEL for the school year per student were calculated. For all districts, students who used WEL for at least 100 minutes during a school year were considered to have used the program during that year; students who used WEL for less than 100 minutes during a school year were considered not to have used the program during that year. Second grade students in District 3 did not use WEL.

To assess overall effects, long-term effects, and early effects, usage groups were formed based on the differing numbers of school years in which students had usage between kindergarten, first grade, and second grade (Tab. 1). To assess overall effects of CAI use, the experimental group included students who used CAI during kindergarten, first grade, and second grade, and the control group included students who did not use CAI during all three school years. No students in District 3 used WEL during second grade; as a result of the delay between usage and assessment at the end of second grade, overall effects were not assessed for District 3. To assess long-term effects of CAI use, the experimental group included students who used CAI during kindergarten and first grade but did not use CAI during second grade, and the control group included students who did not use CAI during all three school years. To assess early effects of CAI use, the experimental group included students who used CAI during kindergarten in addition to later grades, and the control group included students who did not use CAI during kindergarten.

Assessments were administered to all students at the end of second grade.

	District 1	District 2	District 3	Usage Group Comparisons
Total 2nd Grade Students	5,002	1,796	1,849	
3 Years of Usage Experimental	2,108	585	-	Overall Effects, Early Effects
K & 1st Grade Usage Experimental	288	478	1,228	Long-Term Effects, Early Effects
No Usage Control	593	142	287	Overall Effects, Long-Term Effects
No K Usage Control	729	137	278	Early Effects

Table 1: Participants by District and Usage Group Comparisons

Findings**Group Differences Using Independent Samples *t*-tests**

Independent samples *t*-tests were conducted to examine group differences in end of second grade scores between experimental and control groups (Figs. 1-3).

Overall Effects

In District 1, analysis of end of second grade scores revealed a significant difference between groups for Dictation Sounds, $t(1, 673) = -3.97, p < .01$, and Dictation Words, $t(1, 729) = -3.10, p < .01$, due to higher end of second grade scores made by experimental students than by control students.

In District 2, analysis of Overall Reading end of second grade scores revealed a significant difference between groups, $t(1, 725) = -3.23, p < .01$, due to higher end of second grade scores made by experimental students than by control students.

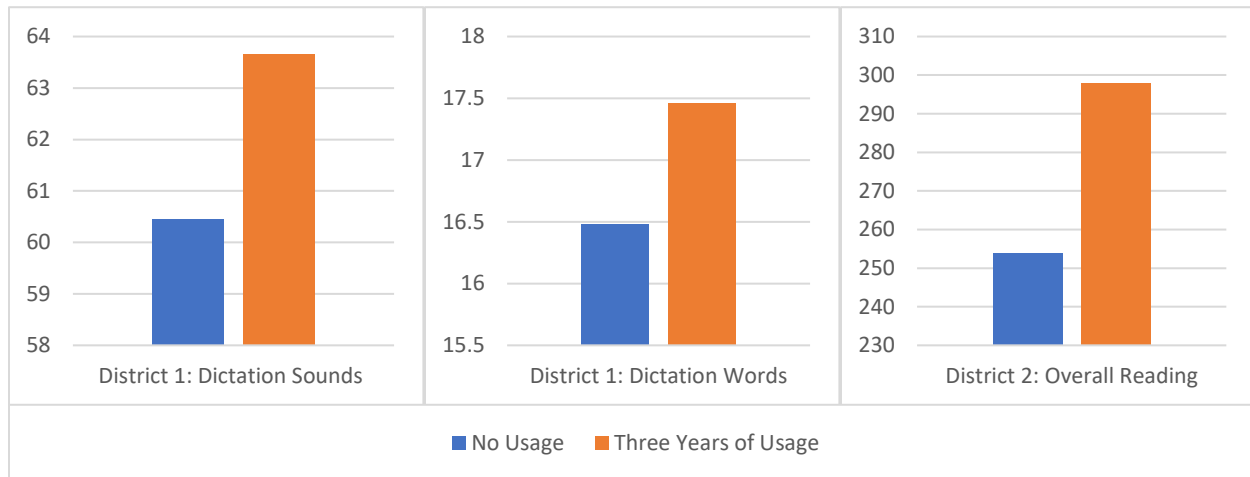


Figure 1: Overall Effects - Group Differences in End of Second Grade Scores

Long-Term Effects

In District 1, analysis of Dictation Sounds end of second grade scores revealed a significant difference between groups, $t(1, 702) = -2.30, p < .05$, due to higher end of second grade scores made by experimental students than by control students. Analysis of Dictation Words end of second grade scores did not reveal a significant difference between groups, $t(1, 821) = -1.18, p = .231$; however, end of second grade scores made by experimental students were higher than scores made than by control students.

In District 2, analysis of Overall Reading end of second grade scores revealed a significant difference between groups, $t(1, 618) = -5.01, p < .01$, due to higher end of second grade scores made by experimental students than by control students.

In District 3, analysis of Overall Reading end of second grade scores revealed a significant difference between groups, $t(1, 317) = -7.17, p < .01$, due to higher end of second grade scores made by experimental students than by control students.

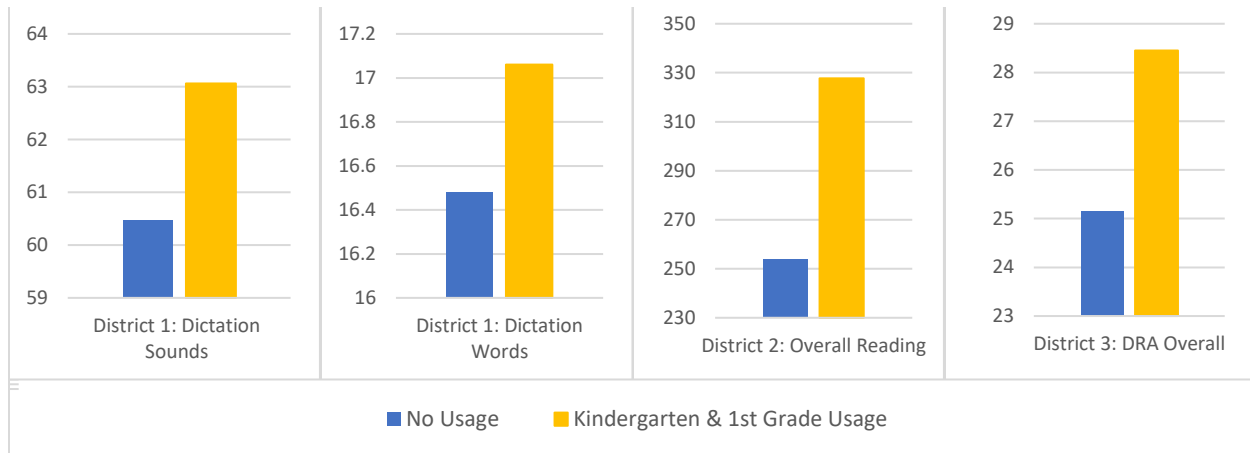


Figure 2: Long-Term Effects - Group Differences in End of Second Grade Scores

Early Effects

In District 1, analysis of end of second grade scores revealed a significant difference between groups for Dictation Sounds, $t(1, 1029) = -3.44, p < .01$, and Dictation Words, $t(1, 1126) = -2.10, p < .05$, due to higher end of second grade scores made by experimental students than by control students.

In District 2, analysis of Overall Reading end of second grade scores revealed a significant difference between groups, $t(1, 720) = -2.77, p < .01$, due to higher end of second grade scores made by experimental students than by control students.

In District 3, analysis of Overall Reading end of second grade scores revealed a significant difference between groups, $t(1, 1432) = -2.71, p < .01$, due to higher end of second grade scores made by experimental students than by control students.

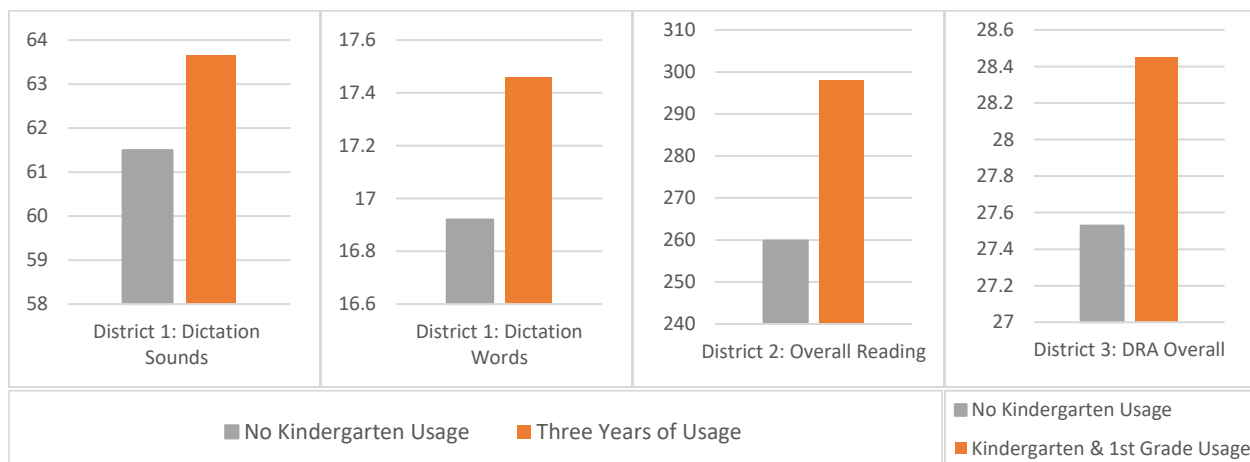


Figure 3: Early Effects - Group Differences in End of Second Grade Scores

Conclusions

In this longitudinal study, reading skills of early elementary students were followed across multiple years. Longitudinal research investigating educational technology is sparse, and evidence-based interventions need to be bolstered by longitudinal research to show the long-term impact of curricula to best support young students throughout their schooling.

In this study, all hypotheses were supported. In both districts in which overall effects were assessed, students who consistently used WEL for three years significantly outperformed control students on all strands assessed, including Dictation Sounds, Dictation Words, and Overall Reading. Students who used CAI for three years, the critical early years of their elementary school education, outperformed their control counterparts who did not use CAI on various literacy strands and across three districts – this finding indicates a positive overall effect of the use of CAI on students' test scores. Research shows that early literacy skills are interrelated during the early elementary school years, and this finding supports the use of computer-adaptive reading programs by students in early elementary school grades.

When long-term effects were assessed, students who previously used WEL outperformed control students on all strands assessed and in all three districts: Experimental students significantly outperformed their control counterparts on two out of the three strands including Dictation Sounds and Overall Reading. The benefits of WEL were evident after not using the program during their second grade year, demonstrating that CAI has a lasting effect on students' literacy skills; as students progressed through their schooling, they still benefited from the use of CAI. This finding indicates a long-term positive effect of the use of CAI on students' test scores.

Across all districts, students who started using WEL during kindergarten, and consistently used for two or three years, significantly outperformed students who started using the program one year later on all strands assessed, including Dictation Sounds, Dictation Words, and Overall Reading. Students who started using CAI early benefited in a way that students who started using CAI later did not, a finding which indicates that there is an effect of the early use of CAI on students' test scores. As findings from the current study support both long-term and early effects, this would suggest that CAI approaches should be implemented early in students' academic careers to achieve the best possible results for student learning outcomes.

The current study is limited in that it does not follow students beyond second grade. While it does speak to how academic trajectories are being shaped in their first vital years, it cannot address them beyond that time frame. Future research would benefit from following students through the whole of their education.

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