

Using computer-assisted instruction to fidelity to combat learning loss in early learners

Abstract: This study examined the degree to which fidelity of usage moderates the efficacy of a targeted computer-assisted instruction (CAI) program. Analysis of end of program scores revealed that students who used the program to fidelity, for at least 1,350 minutes, during the summer prior to the start of kindergarten, significantly outperformed students who did not use the program to fidelity, with less than 750 minutes of total usage, on a measure of early reading skills. Across all demographics assessed (ethnicity, gender, socioeconomic status, preschool attendance, and primary language) students who used the program to fidelity outperformed students who did not. The results of this study point to the important role that CAI usage plays in addressing summer learning loss.

Introduction

The “summer slide” is a seasonal period of untapped learning time, during which variations in home learning environments lead to differential growth of academic skills both within and between populations of students [1]. Parents of children from higher socioeconomic (SES) households are able to provide richer at-home learning activities, and out-of-home activities during both the school year and summer months [2]. These differences in learning environments can, over time, lead to compounding learning deficits for students across demographic lines where students from low SES, minority, and dual language learner backgrounds must make up for more and more lost time on a year-by-year basis [3]. According to the findings of a study investigating academic growth in children from kindergarten through 5th grade, not only did score gaps widen faster during the summer between school years, but achievement gaps were already present before children started kindergarten. Further, early childhood is the primary source of the achievement gaps between children from high and low SES, and between children from different racial and ethnic backgrounds [4].

High-quality early childhood education programs can help narrow achievement gaps [5] and attending preschool before entering kindergarten can help children acquire early literacy skills [6]. However, both dosage and the preschool program type may contribute differently. Experiencing a higher dosage of a preschool program with an academic focus is also associated with higher preliteracy outcomes, particularly for African American students [7]. Studies of summer kindergarten readiness programs have shown that at-risk student attendees [8] and those without prior preschool experience [9] experience significant early literacy skill growth.

Educational technology may have the potential to help close achievement gaps by providing evidence-based early education instruction at-home. Computer-assisted instruction (CAI) is an educational approach which utilizes adaptive and engaging multimedia software to improve student learning outcomes by providing interactive activities and feedback at a student’s individual difficulty level. CAI can provide a cost-effective individualized learning environment, which can be widely distributed to provide targeted literacy instruction over the summer, before the start of kindergarten.

Available research on the effectiveness of CAI use in schools indicates that CAI can help improve early reading skills for young students [10], including preschool students from low-SES households [11], and minority students if the content is culturally relevant [12]. Further, earlier CAI use, and using CAI over multiple years is associated with significantly higher achievement on early reading assessments [13]. The relationship between increased CAI usage and educational outcomes is not clear [14], and more research is needed to determine the relationship between academic outcomes and CAI fidelity [15].

Limited research has been conducted on the effectiveness of computer-based early literacy instruction during the summer prior to kindergarten. One recent study investigated the effectiveness of two

computer-based reading programs, with a parent training component. Kindergarten to third grade students who used either program for twenty hours over an 8-week period, experienced significant gains in measures of early literacy skills. However, the sample sizes were small, and the study did not examine the effects of the program by grade [16]. The aim of this study is to expand on the current body of research regarding the effectiveness of CAI instruction during the summer prior to kindergarten.

This research comes at an important time, COVID-19 forced many young children to miss large portions of schooling and has exacerbated existing systemic issues [17]. Recent literature has warned that the disruption resulting from the pandemic threatens to lead to a global education crisis [18]. Pandemic related deficits have also been found specifically when looking at the acquisition of foundational literacy skills [17]. When the oral reading fluency skills of elementary school students were examined in the spring of 2020 students showed growth well below what had been considered typical in previous years, with scores for students in poorer districts declining at a disproportionate rate. In this critical period, it is more important than ever to pursue effective interventions to mediate learning loss.

The current study examines the impact of fidelity on learning outcomes for a targeted CAI summer program for students in the months prior to entering kindergarten. It is predicted that students that use the program to fidelity, students with at least 1,350 minutes of usage during the program, will outperform students that do not use the program to fidelity, students with less than 750 minutes of usage during the program.

Methods

Participants

This initial sample for this study consisted of four-year-old students ($N = 3,082$) across 11 states during the summer of 2021 before their kindergarten year. The sample was 34.01% Caucasian, 27.48% African American, 22.06% Hispanic, 5.71% Asian, and other ethnicity accounting for 10.74% of the sample. 85.62% of the students in the sample spoke English as their primary language. The sample was 48.96% female. 59.25% of the sample lived below 185% of the poverty line. The analytic sample ($n = 661$) was limited to students with beginning and end of program assessment scores.

Materials

Waterford Upstart

A home-based, technologically enabled, kindergarten readiness program. Through Upstart, families are provided with equipment and coaching in order to facilitate parental involvement and student engagement. The program gives students access to an adaptive early literacy curriculum and prepares them for academic success in kindergarten.

Waterford Reading Academy (WRA)

WRA 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.

The Waterford Assessment of Core Skills (WACS)

WACS is an adaptive assessment designed to assess 11 key pre-literacy and reading skills. Initial content validity for WACS was established against state and national standards for the 11 subtests. All items were then calibrated for Item Response Theory to determine item difficulty. To establish concurrent validity and predictive validity student performance on WACS was compared to performance on five commonly used standardized tests also measuring early reading skills; all correlations between tests are significant,

ranging from $r = .41$ to $r = .78$ (median $r = .63$). Additional analyses indicate that WACS is internally consistent and has strong test-retest reliability ($r = .90$).

Procedure

Students that participated in the program were expected to use WRA for 20 minutes a day, five days per week. Usage was tracked within the program and monitored weekly, and total minutes of the adaptive curriculum usage for the duration of the program per group was calculated. The experimental group ($n = 323$) included students who used WRA for at least 1300 minutes during the summer learning program (SLP). The control group ($n = 338$) included students who used WRA for less than 750 minutes during the SLP. WACS was administered at the beginning and end of the program to assess the literacy skills of the students before and after their participation in the program. Note that because it was not possible to administer the WACS assessment in person because of COVID-19, start of program results were adjusted based on previously proctored Upstart participants.

Findings

Group Differences Using Independent Samples t-test

Independent samples t-tests were conducted to examine group differences in beginning and end of program scores between the experimental and control groups (see Table 1, Fig. 1).

Analysis did not reveal a significant difference in beginning of program scores between groups, $t(1, 657) = 0.99$, $p = .324$. Start of program scores made by experimental students ($M = 1992.37$) and control students ($M = 1963.43$) were comparable to each other.

Analysis revealed a significant difference in end of program scores between groups, $t(1, 659) = 4.01$, $p < .05$, due to the higher end of program scores made by experimental students ($M = 2701.57$) than by control students ($M = 2525.28$). Effect size ($d = 0.31$).

Group Differences Using ANOVAs

Five two-way ANOVAs were performed to examine the impact of demographics and SLP on average end of program scores (see Table 1). Analysis indicated that there were no significant interactions found for the effects of the SLP program and ethnicity, gender, socioeconomic status, prior attendance of another preschool program, or a student's primary language. Simple effects analysis indicated that for all comparisons between experimental and control group students, across all demographics considered, students in the experimental group consistently outperformed students in the control group. End of program scores for Asian and Hispanic students, female students, students below 185% poverty, and students whose primary language was not English scores in the experimental group were slightly higher than in the control group, but the difference was not significant.

Discussion

Educators are facing an unprecedented challenge as young students are experiencing learning loss, due to both a summer slide effect as well as from disruption due to COVID-19 [1, 17]. These effects are especially concerning for students who are already at risk of academically falling behind their peers throughout their elementary school years, including students from low SES households, minority students, and English language learners [4]. In order to provide the best experience for their students, educators should seek out programs and interventions that are research-based and provide a meaningful impact on students' learning when used to fidelity.

The current study directly compared end of program scores between students who used the CAI software to fidelity and students who did not use the software for a meaningful amount of time. Results support our hypothesis that students who had higher usage by the end of the program, at least 1,350 minutes, scored significantly higher on the end of program literacy assessment compared to students who did not use the software to fidelity, with less than 750 minutes. The overall effect size of 0.31 can be considered a meaningful moderate effect according to Cohen's conventions [19]. Positive results were seen throughout the sample of students, as students in the experimental group outperformed students in the control group across all demographics, including ethnicity, gender, socioeconomic status, primary language, and whether or not the student attended preschool. These outcomes expand on the body of literature demonstrating positive effects of high-quality early childhood education programs, [7] and the moderating effect played by fidelity in CAI implementations [15].

Although the positive results of this study can be generalized across demographics, one limitation in the design is that students were not assessed beyond the end of the summer program. Future research would benefit from assessing students' literacy skills during their kindergarten school year, to determine long term impact of the summer program. This could expand further on benefits of using CAI to mitigate learning loss due to summer slide and COVID-19.

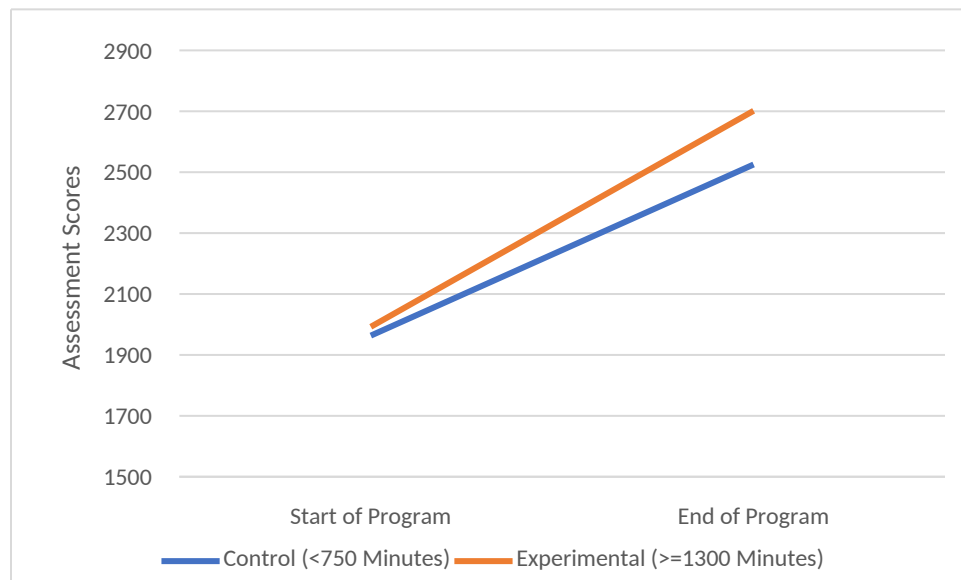
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Table 1. Assessment Scores by Demographics

		Control (<750 Minutes)			Experimental (≥1300 Minutes)			<i>p</i>
		<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	
Overall	Start of Program	338	1963.43	395.049	323	1992.37	359.469	0.32
	End of Program	338	2525.28	558.221	323	2701.57	571.615	0.00**
Ethnicity	African American	99	2490.64	557.96	76	2693.76	628.56	0.02*
	Asian	14	2633.86	530.15	34	2947.62	517.52	0.08
	Caucasian	81	2569.42	575.90	90	2775.11	497.28	0.02*
	Hispanic	93	2401.33	505.29	82	2487.70	536.14	0.30
	Other	46	2726.09	597.37	38	2792.03	606.47	0.59
Gender	Female	185	2550.70	572.00	142	2664.25	558.41	0.07
	Male	153	2494.54	541.36	181	2730.85	581.63	0.00**
Socio-economic Status	Over 185% Poverty	106	2590.00	485.30	122	2829.25	496.95	0.00**
	Under 185% Poverty	170	2470.42	565.78	171	2575.65	572.90	0.07
Preschool Attendance	No Other Preschool	197	2525.07	540.74	207	2739.92	588.60	0.00**
	Other Preschool	141	2525.57	583.72	116	2633.14	535.65	0.13
Primary Language	English	268	2541.80	557.49	243	2761.15	569.19	0.00**
	Non-English	65	2447.55	566.26	77	2517.32	539.28	0.46

* $p < .05$, ** $p < .001$

**Figure 1.** Beginning and End of Program Assessment Scores